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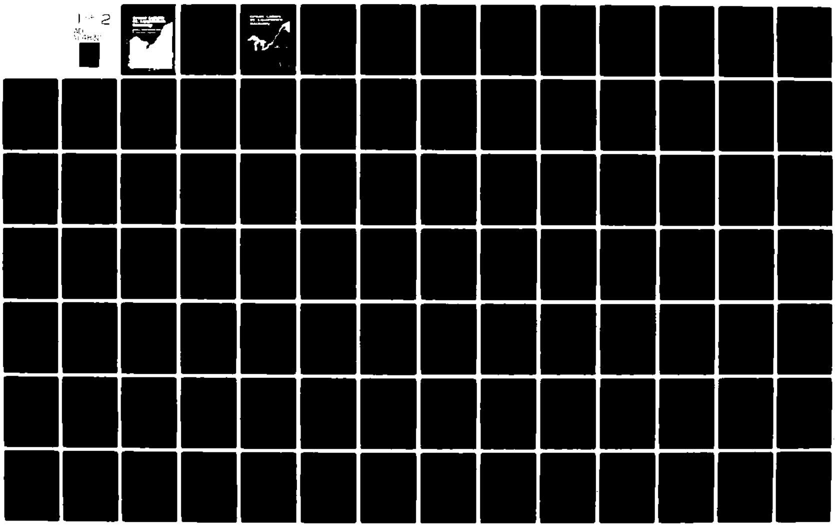

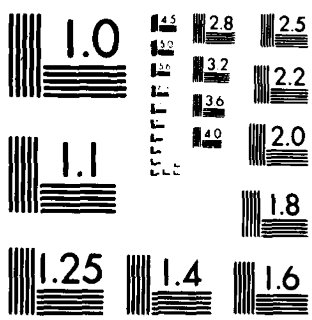

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Impacts related to lock system improvement in the Great Lakes are investigated in this report. Methodologies and procedures are generally based upon secondary data or related studies. Positive or adverse impacts are related to either specific types of structural or non-structural modifications or directed towards specificmodes of transportation.

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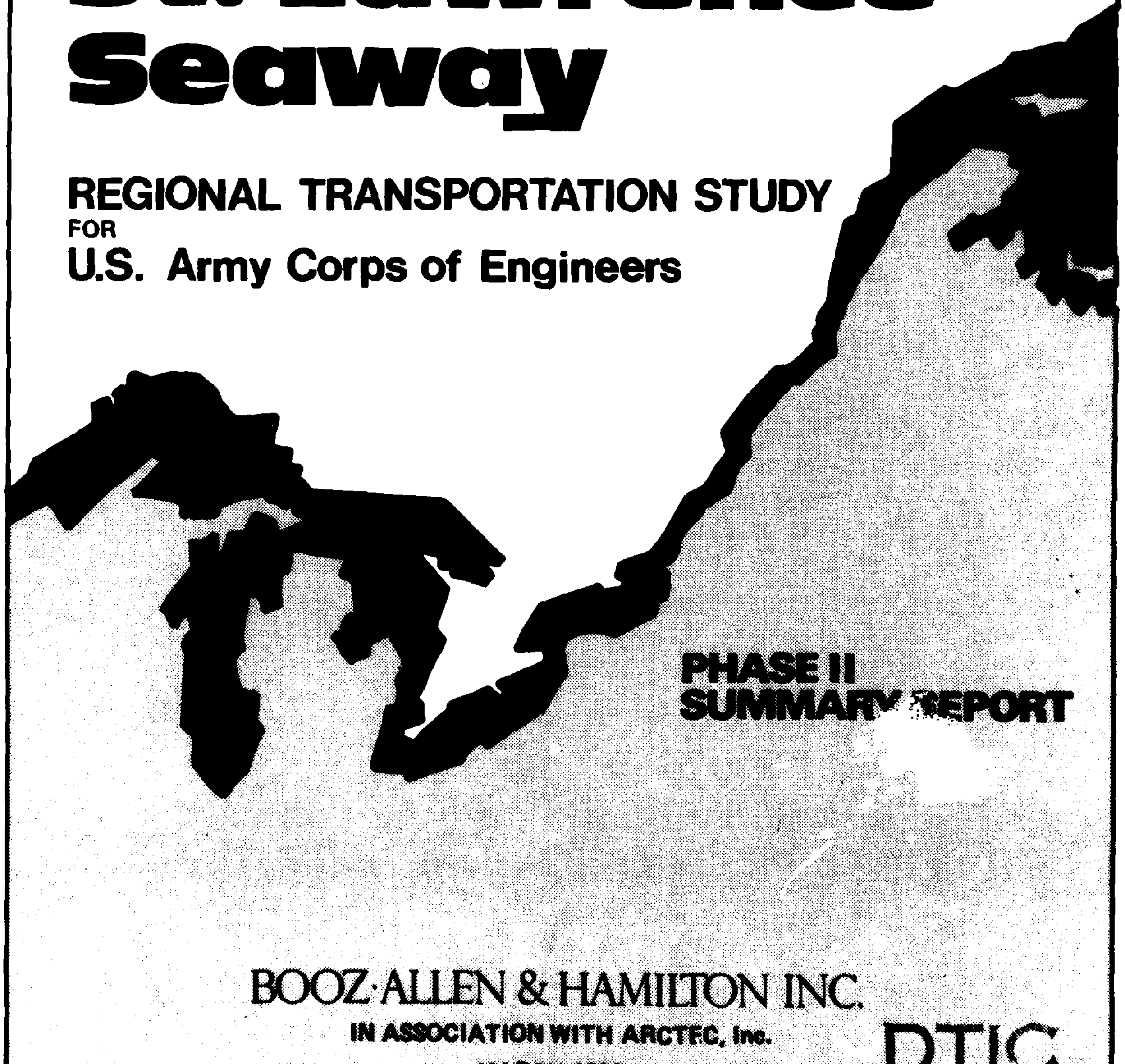

PHASE II
SUMMARY REPORT

BOOZ·ALLEN & HAMILTON INC.
IN ASSOCIATION WITH ARCTEC, Inc.
MARCH 1982

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I. INTRODUCTION

The U.S. Army Corps of Engineers is responsible for maintaining navigability in U.S. rivers, waterways, and harbors. The Corps currently maintains a navigation system of 25,000 miles of improved channels and 219 locks and dams connecting large regions of the country. Feasibility analyses and planning that precede lock and channel construction and maintenance are integral components of navigation system projects. The Great Lakes/St. Lawrence Seaway Regional Transportation Study is one element of this planning process.

The objective of the GL/SLS Regional Transportation Study is to develop an up-to-date, working analytical tool for economic analysis of GL/SLS transportation system improvements. The near-term uses of study information are feasibility studies of three Great Lakes navigation system improvements. These studies are the following:

- The St. Lawrence Additional Locks Study, which will determine the adequacy of the existing locks and channels in the U.S. section of the seaway in light of present and future needs.
- The Great Lakes Connecting Channels and Harbor Study, which will determine the feasibility of providing navigation channel, harbor and lock improvements to permit transit of vessels up to the maximum size permitted by the possible replacement locks at Sault Ste. Marie.
- The Great Lakes-St. Lawrence Seaway Navigation Season Extension Study, which considers the feasibility of means of extending the navigation season on the entire system.

The study is organized in two phases. Phase I has the following elements:

- Development of cargo flow forecasts for the Great Lakes system

- Development of data bases required for the evaluation of national economic development (NED) benefits and costs of navigation system improvements

- Evaluation of lock system performance and ability to process future cargo flows

- Evaluation of the performance and economic feasibility of improvements to increase the capacity of the system.

Phase II of the study, documented in this report, assesses the regional economic, social, intermodal, and energy use impacts of alternative improvements.

II. SUMMARY

The direct benefits of lock system improvements are rate savings resulting from continued use of the system instead of cargo being forced to use a more expensive route and mode, reduced delay at congested locks, and improved vessel productivity resulting from more cargo per locking operation.

This report evaluates other impacts of lock system improvements. These include:

- Energy savings which occur because lake transportation, which is relatively fuel-efficient, can continue to be used
- Induced industrial production potentially resulting from reduced lake freight rates
- Regional economic impacts, including port employment and income which are directly related to Great Lakes commerce
- Environmental and social impacts which might result from increased traffic or lock construction
- Intermodal impacts, which are measured in terms of net revenue gains or losses which would be incurred by the freight modes serving the Great Lakes region.

The evaluation of these potential impacts is summarized below.

1. ENERGY SAVINGS

The potential energy savings resulting from structural improvements to the upper and lower lock systems are summarized in Tables II-1 and II-2, respectively.

In general, improvements to the lower lock system produce smaller energy savings than improvements to the upper lock system because higher tonnages use the upper lock system. Structural improvements involving larger locks in general produce higher energy savings than those involving deepening of channels. Most of the energy savings resulting from upper locks improvements are attributable to iron ore, while at the lower locks energy savings are primarily attributable to general cargo.

TABLE II-1
Potential Energy Savings
(Upper Locks)

	(Trillion Btus per Year)				
	2010	2020	2030	2040	2050
1350 X 115 Foot Locks	1.9	6.7	11.9	17.6	23.1
1460 X 145 Foot Locks	1.9	6.7	11.9	17.6	23.1
23 Foot System Draft	1.9	6.7	9.8	9.8	9.8
32 Foot System Draft	1.9	6.7	11.9	19.2	19.2

Note: All energy savings reflect implementation of non-structural improvements to maximum utility before structural improvements are implemented.

TABLE II-2
Potential Energy Savings
(Lower Locks)

	(Trillion Btus per Year)						
	1990	2000	2010	2020	2030	2040	2050
1350 X 115 Foot Locks	(1.3)	(1.8)	1.2	2.0	4.4	6.6	8.1
1460 X 145 Foot Locks	(1.3)	(1.8)	1.2	2.0	5.1	7.2	10.1
28 Foot System Draft	(1.3)	(1.8)	1.3	1.8	3.2	3.8	3.8
32 Foot System Draft	(1.3)	(1.8)	1.3	2.4	4.9	6.5	7.7

Note: All energy savings reflect implementation of non-structural improvements to maximum utility before structural improvements are implemented.

In 1977, U.S. freight transportation accounted for about 6.66 quadrillion Btus. The potential energy savings for 2030 identified above are 0.1 percent of the total; while these potential fuel savings are important, they represent a very small percentage of total fuel consumed for freight transportation.

2. INDUCED INDUSTRIAL PRODUCTION

Structural improvements could reduce lake freight rates because larger ships could be used (if larger locks were built) or ships could be loaded with more cargo (if system draft were deepened). Freight rate reductions of up to 30 percent could be achieved by the structural improvements analyzed in this report.

It is doubtful, however, that these freight rate reductions by themselves could induce higher industrial production in Great Lakes states. The potential impacts on the grain, coal and steel industries are discussed below.

(1) The Grain Industry

The Great Lakes/St. Lawrence Seaway handles less than 15 percent of total U.S. grain exports. Fluctuations in grain transportation costs are normal and do not appear to affect export levels. Several economic factors influence grain production levels much more than transportation prices. A 20 percent reduction in freight rates would reduce the delivered price of grain by only 2 to 3 percent. Demand for wheat and corn is relatively insensitive to this level of price change, and it is highly doubtful that such a reduction in total prices would open new markets or increase existing demand.

(2) The Coal Industry

Virtually all of the coal moving on the Great Lakes is bituminous coal. Most of the coal is mined in the U.S., more than 50 percent moves to domestic destinations, and most of the remainder is exported to Canada. The primary markets for this coal are electric utilities.

A 20 percent reduction in Great Lakes freight rates would cause only a 1 percent reduction in the delivered price of Appalachian coal, and a 4 percent reduction in the delivered price of western coal. This reduction is less than the average increase in the mine price of coal in the last few years. Since the price of electricity is heavily influenced by the

cost of generating equipment, the potential price reduction passed on to the consumer would be minimal, and would probably not be a factor in the demand for electricity.

(3) The Steel Industry

U.S. steel production is concentrated in the Great Lakes region, where the lakes are essential for iron ore transportation. Water transportation accounts for about 13 percent of the delivered price of iron ore, and the cost of iron ore is about 13 percent of the cost of finished steel. Consequently, a 30 percent decrease in iron ore transportation cost will produce only a 0.5 percent reduction in the cost of steel. This price reduction is not significant and would not influence the demand for steel.

3. REGIONAL ECONOMIC IMPACTS

Port activity generates tangible business activity for firms which participate in the transfer of cargo between ship and port, and which provide support services for ships while in port. In this study, port economic impact is measured in terms of income and employment. These two parameters are related by the wages of the sectors participating in port activity.

Table II-3 summarizes regional economic impacts resulting from 1350 by 115 foot locks. This lock improvement program will protect almost 4400 port employment positions in 1985, which would be lost if additional traffic were not able to use the Great Lakes system. The employment impact increases to 7300 jobs in the year 2010 and 23,000 positions by 2050. Regional economic impacts produced by even larger locks or deeper channels will be similar to those shown in the table.

Direct income related to port activity protected by the improvement program amounts to $97 million in 1985, increasing to $164 million in 2010 and $547 million in 2050. Part of this income would be respent within the local economy. For this analysis it was assumed that for every one dollar of income earned in the port community, an additional 40 cents is generated as a result of purchases of locally produced goods and services.* This results in an income multiplier of 1.4.

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* Estimated by the Regional Income Multiplier System of the Bureau of Economic Analysis, U.S. Department of Commerce.

TABLE II-3
Summary of Regional Economic Impact
(1350 X 115 Foot Locks)

	1985	1990	2000	2010	2030	2050
Employment (number of jobs)						
Bulk cargo	163	255	363	1,393	5,679	10,268
General cargo	4,228	2,079	2,911	5,933	10,660	13,213
	4,391	2,334	3,274	7,326	16,339	23,481
Direct Income ($ million)						
Bulk cargo	4	6	9	34	141	256
General cargo	93	45	64	130	235	291
	97	51	73	164	376	547
Total Income Including Respending ($ million)	136	71	102	230	526	766

Note: This table identifies potential losses unless a capacity condition is corrected.

Income including respending is also shown in Table II-3. Total income is expected to be $136 million in 1985, increasing to $230 million in 2010 and $766 million in 2050.

4. ENVIRONMENTAL AND SOCIAL IMPACTS

Potential environmental and social impacts resulting from lock system improvements could be caused by dredging and lock construction, increased vessel traffic and the movement of larger vessels through these waterways. Areas which could be affected are discussed below.

(1) Biological Impacts

System improvements will create some physical alteration of sediment in nearshore zones and connecting channels. However, biologic communities and aquatic vegetation will probably adjust to this disturbance in a relatively short period of time.

(2) Impacts on the Physical Environment

Air, water and noise pollution associated with increased vessel traffic is expected to be minimal. There is concern, however, about the increased potential for accidental spills of fuel and petroleum cargoes due to founderings and collisions.

(3) Impacts on the Quality of Life

It is not expected that lock construction, channel deepening or increased vessel activity will cause any substantial impact on the recreational uses of the lakes or on aesthetic values.

5. INTERMODAL IMPACTS

Intermodal impacts are measured in terms of the net increase or decrease of line-haul freight revenues accruing to the major segments of the U.S. freight carrier industry: railroads, motor carriers, barge operators and the U.S.-flag Great Lakes and foreign trade fleets. These potential impacts were estimated by comparing modal revenue shifts with total annual revenues of each mode.

Table II-4 summarizes the intermodal impacts resulting from non-structural improvements for maximum utility, followed by 1350 by 115 foot locks. These impacts are summarized below.

- Lake carriers: The with-project case allows lake carriers to receive $10.3 million in revenue in 1985 that would have been lost if the system

TABLE II-4
Summary of Intermodal Impacts
($ million)

	1985	1990	2000	2010	2030	2050
Lake Carrier						
Total Revenue	573	650	759	874	1,141	1,150
Net Change	10.33	17.1	30.8	81	311	553
Percent Change	1.8%	2.6%	4.1%	9.3%	27.3%	36.1%
Railroads						
Total Revenue	13,369	15,063	19,433	25,071	41,728	69,452
Net Change	(79)	(99)	(140)	(246)	(668)	(1,030)
Percent Change	*	*	*	*	(1.6%)	(1.5%)
Motor Carriers						
Total Revenues	15,568	17,188	20,952	25,540	37,951	56,394
Net Change	0.7	1.0	1.5	2.7	9.8	17.0
Percent Change	*	*	*	*	*	*
Barge & Towing Industry						
Total Revenues	2,150	2,397	2,980	3,704	5,729	8,845
Net Change	(25)	(34)	(50)	(59)	(101)	(113)
Percent Change	(1.2%)	(1.4%)	(1.7%)	(1.6%)	(1.8%)	(1.3%)
U.S. Flag Liner Industry						
Total Revenues	5,488	7,004	11,409	13,907	20,665	30,708
Net Change	(20)	(18)	(14)	(15)	(52)	(64)
Percent Change	*	*	*	*	*	*

* Less than 1 percent.

Note: Reflects non-structural improvements to maximum utility, followed by 1350 x 115 foot lo

reached capacity. This revenue increases to $30.8 million in 2000 and $553 million in 2050. This represents 1.4 percent of this industry's revenue in 1985, increasing to 4.1 percent by 2000 and 36 percent by 2050.

- Railroads: The with-project case means a loss of the opportunity to collect $79 million in revenues in 1985, increasing to $140 million by the year 2000 and more than $1 billion in 2050. This is less than 2 percent of expected revenues in any of these years, however.

- Barge and towing industry: The with-project case means the loss of the opportunity to collect $25 million in revenue in 1985, increasing to $50 million in 2000 and $113 million in 2050. Similarly, this is less than 2 percent of total revenues in any of these years, however.

- Motor carriers: The with-project case means a change of less than 1 percent in any year until 2050.

- U.S. flag liner industry: The impact on the liner industry is negligible.

A positive impact means that the with-project case benefits the industry by allowing it to be able to handle traffic that would otherwise be forced off the system. The modes affected positively are the lake carriers and motor carriers. A negative impact means that lock improvements cause a modal industry to lose the opportunity to move traffic that would have been forced off the system in the absence of improvements. The modes affected negatively are railroads, the barge and towing industry and the U.S. flag liner industry. Except for the lake carriers, modal impacts even by the year 2050 can expect to remain at less than 2 percent of gross revenues.

The volume and commodity mix of the tonnage able to use the system after other types of structural improvements (larger locks and deeper channels) will be similar to that associated with 1350 by 115 foot locks. The intermodal impacts are expected to be similar as well.

III. ENERGY IMPACTS

This chapter estimates the energy impacts that would result from Great Lakes/St. Lawrence Seaway lock system improvements. The first section of the chapter describes the methodology used to estimate these energy impacts. The second section presents the results of the analysis.

1. METHODOLOGY

This section provides an overview of the methodology used to develop and apply modal energy-intensity factors to estimate energy impacts.

(1) Introduction

Previous assessments of Great Lakes navigation system improvements* have identified these areas of energy impact:

- Changes in energy consumed in line-haul freight operations
- Changes in energy consumed as a result of reductions in stockpiles of bulk commodities
- Energy expended in construction of new or expanded facilities.

The navigation system improvements considered in this study include non-structural and structural improvements at the Soo Locks, Welland Canal and St. Lawrence Seaway in order to relieve expected capacity conditions and to allow more traffic to transit each lock system per year. These improvements will not extend the navigation season and therefore will not alter bulk commodity stockpiles. Energy expended in construction of new or additional facilities would occur only at the beginning of the project's life cycle, and is expected to be minimal compared to

* TERA, Inc., The Energy Impact of GL/SLS Navigation Season Extension, 1978.

transportation energy consumption.* Consequently, this chapter is concerned only with the changes in energy consumed in line-haul freight operations.

1. Objective of the Analysis

The objective of the analysis was to develop fuel consumption rates for each mode of freight transportation which are measures of the energy-intensiveness of these modes. These fuel consumption rates were then applied to existing and future freight movements to determine the change in energy consumption between "with-project" and "without-project" conditions. The "without-project" case involves traffic which is assumed to be unable to use a lock system and which is carried on another route and mode. The "with-project" case assumes that lock capacity is increased and this traffic continues to use the lock system.

2. Summary of Previous Research

Table III-1 summarizes several sources of modal energy-intensiveness factors. The methodologies used to compute these factors can be viewed along a macro-micro spectrum. At the broadest end are the calculations which take annual fuel consumption along with transportation production statistics to compute annual system wide intensiveness measures. This is the basic approach of Mooz, Hirst, Rice and Tihansky. At the other end of the methodological spectrum are those calculations which begin with an engineering computation of the motive power and then aggregate successive elements of the transportation production process to compute total modal energy consumption. The work of DOT/NASA and the National Petroleum Council (NPC) are closest to this end. Between these two extremes are a variety of combination methodologies. The parameters are based on quantitative considerations such as differences in load factors, circuity, backhauls, terminal operations, pickup and delivery requirements, and

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* This was the conclusion of The Energy Impact of GL/SLS Navigation Season Extension.

TABLE III-1
Sources of Energy-Intensiveness Data

MODE	TON-MILES PER GALLON	BRITISH THERMAL UNIT PER TON-MILE	SOURCE	REMARKS
Heavy-	59	2300	Rice (15)	Based upon mid-1960 data
Duty	57	2400	Mooz (37)	Based upon 1967 data
Truck	49	2800	Hirst (13)	Based upon late 1960's data
(Combinations)	123-67	1110-2023	DOT/NASA (17)	Engineering estimate (optimistic)
	51	2679	TSC (12)	Based upon 1972 highway statistics
	41	3440	Mitre (16)	
	85	1600	DOT/EPA (26)	Based upon year 1972 ATA data
	29-103	4690-1320	French (36)	Four-case study to illustrate operational factor impact
Railway	203	680	Rice (15)	
	184	750	Mooz (37)	
	212	650	Smith (38)	Modification of Mooz (37) to eliminate data errors
	206	670	Hirst (13)	
	418-251	330-550	DOT/NASA (17)	Engineering estimate (optimistic)
	204	676	TSC (12)	
	204	675	Mitre (16)	
	197	700	FEA (8)	Show efficiency decreasing from 650 in 1965 to 700 in 1972
	184	750	Tihansky	
	194-216	639-711	Sebald	Single car
	284-611	226-359	Sebald	Unit train
	203	679	Upper Miss Wat. Assoc.	
	194	711	St. Louis District	
Waterway	259	540	Rice (15)	
	280	500	Mooz (37)	
	214	655	Smith (38)	Modification of Mooz (37) to eliminate data errors
	206	680	Hirst (13)	
	275	509	TSC (12)	
	187	750	Mitre (16)	
	280	500	Tihansky	
	275	510	NPC	
	334	419	Upper Miss Wat. Assoc.	
	216	649	St. Louis District	

Source data usually give efficiency estimates in BTUs per ton-mile. Ton-miles per gallon were calculated using the following conversion factors to provide a uniform pattern throughout the table:

Truck (Diesel Oil)	136,000 Btu/gal
Railway (Diesel Oil)	138,000 Btu/gal
Waterway (Bunker Oil)	140,000 Btu/gal

Source: Reproduced from National Cooperative Highway Research Program, Synthesis of Highway Practice #43, Transportation Research Board, Energy Effects, Efficiencies, and Prospects for Various Modes of Transportation, Washington, D.C. 1977.

routing. Examples are the studies of Sebald, Upper Mississippi Waterway Association, and the St. Louis District Engineer.*

It can be seen from the table that the estimates vary over a wide range. This emphasizes the need for understanding the basic operational parameters reflected in an energy-intensity factor. Consequently, in this study, modal energy-intensiveness factors were calculated based on mileage, tonnage, speed, fuel consumption, equipment configuration and backhaul data that most reasonably represent actual movements by each mode. These factors were then compared to the previous table for reasonableness and consistency with previous research.

It should be noted that energy-intensity factors calculated in this way do not include refinements to variables to which fuel consumption is often highly sensitive. These include:

- Environmental considerations such as aerodynamic resistance, gradients and currents
- Propulsion inefficiencies
- Loading, unloading, fleeting/switching and terminal mileage.

Each energy-intensity factor is expressed in terms of fuel consumption per ton-mile. The following sections describe the development of factors for each mode in detail.

(2) Development of Fuel Consumption Factors

This section describes how fuel consumption factors were developed for each mode of transportation. Overland transportation (rail, truck and barge) and deep-draft water transportation are discussed separately below.

* This review of previous research is excerpted from U.S. Department of Transportation, The Replacement of Alton Locks and Dam 26, September 1975.

1. Overland Modes

(1) Rail

A fuel consumption rate for unit trains is based on the following parameters:

- Train consists of 100 cars
- Car capacity of 100 tons
- Speed of 25.6 miles per hour
- Four six-axle SD-40 locomotives per train, 3000 HP per locomotive
- Fuel consumption per locomotive of 116 gallons per hour, corresponding to throttle position number 5
- Empty backhaul using only one locomotive under power.

These parameters produce a fuel consumption rate of 442 ton-miles per gallon.

Development of an engineering estimate for fuel consumption for single-car rail movements is highly dependent on routing, car switching, train makeup and a variety of other operational parameters. For this reason a fuel consumption rate of 198 ton-miles per gallon was taken from the literature and was used in the analysis.*

(2) Truck

For this analysis, it was assumed that the only use of trucks for intercity bulk shipments to or from Great Lakes ports is for short-distance grain movements, and that all other bulk commodities are carried by rail.

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* David S. Paxson, "The Energy Crisis and Intermodal Competition," presented to the Transportation Research Board, January 1980.

In a previous report* of this study, it was determined that steel and general cargo shipments via the Great Lakes originate or terminate within the port city metropolitan area. Thus it was assumed that the fuel consumption of trucks used for local pickup and delivery of steel and general cargo is negligible compared to the total fuel consumption of the entire movement.

Fuel consumption rates are based on the following parameters:

- A single 45-foot trailer and tandem axle trailer
- Loaded capacity of 25 tons
- Fuel consumption of 4.8 miles per gallon (loaded) and 6.0 miles per gallon (empty)**
- Empty backhaul.

These factors produce a fuel consumption rate of 133 ton-miles per gallon.

(3) <u>Barge</u>

Only two commodities are assumed to move via barge. One is a current movement of steel imports to the Chicago area from New Orleans. The second is export grain that would have moved via Duluth or Chicago that would move by barge to New Orleans if the Great Lakes system reached capacity. A fuel consumption rate for barges is based on the following parameters:

- Capacity per barge of 1,500 tons.
- Twenty percent loaded backhaul of fertilizer and/or salt.
- Average fuel consumption rate of one gallon per day per horsepower. Tables III-2 and III-3 show parameters used in the calculations.

* <u>Analysis of Freight Rates</u>, December 1981.

** American Trucking Association.

TABLE III-2
Barge Fuel Consumption Parameters
(Chicago - New Orleans)

	Illinois Waterway	Middle Mississippi*	Lower Mississippi**	Total
Tow size (number of barges)	15	20	30	
Tons per barge string (15T/barge)	22,500	30,000	45,000	
Average speed (mph)	4.0	8.0	8.0	
Distance (miles)	192	180	843	
Towboat horsepower	4,500	6,500	8,500	
Time in transit, one way (hours)	48	22.5	105.4	
Fuel consumption, one way (gallons)†	9,000	6,094	37,329	
Fuel consumption required for 45,000 tons, downbound (gallons)†	18,000	9,141	37,329	64,470
Ton-miles downbound				54,675,000
Ton-miles upbound at 40% utilization				21,870,000
Total ton-miles				76,545,000
Total fuel consumption (gallons)				129,940
Ton-miles per gallon				594

*Alton-Cairo.
**Cairo - New Orleans).

†At one gallon per horsepower—day.

TABLE III-3
Barge Fuel Consumption Parameters
(Minneapolis - New Orleans)

	Upper Mississippi	Middle Mississippi*	Lower Mississippi**	Total
Tow size (number of barges)	15	20	30	
Tons per barge string (15T/barge)	22,500	30,000	45,000	
Average speed (mph)	4.5	8.0	8.0	
Distance (miles)	650	180	843	
Towboat horsepower	4,500	6,500	8,500	
Time in transit, one way (hours)	144.4	22.5	105.4	
Fuel consumption, one way (gallons)†	27,075	6,094	37,329	
Fuel consumption required for 45,000 tons, downbound (gallons)†	54,150	9,141	37,329	100,620
Ton-miles downbound				75,285,000
Ton-miles upbound at 40% utilization				30,114,000
Total ton-miles				105,399,000
Total fuel consumption (gallons)				201,240
Ton-miles per gallon				524

*Alton-Cairo.
**Cairo-New Orleans.

†At one gallon per horsepower—day.

The resulting barge fuel consumption rates are 594 ton-miles per gallon for the Chicago-New Orleans route and 524 ton-miles per gallon for the Minneapolis-New Orleans route.

The method described above produces fuel consumption rates per mile actually traveled. These factors will be subsequently applied to route distances in order to estimate fuel consumption. The impact of route circuity is evaluated as follows.

Point-to-point distances for truck and barge traffic reflect actual highway distance and river milepoint distance, respectively, so no circuity factor is applied. Rail routes are acknowledged to be more circuitous than highway routes; a recent report indicates that the average circuity of rail traffic routings is about 27.3 percent times that of highway routings.* Long-haul rail routes are even more circuitous because more than 70 percent of all rail traffic is interlined with other railroads, and there is a strong economic incentive for a railroad to maintain control of a shipment for as long a distance as possible before turning it over at an interchange point. Another recent study investigated ten actual rail routings of volume movements of export grains from the Midwest to the Gulf (one of the major routings evaluated in the present study). The circuity of these actual routings ranged between 19 and 88 percent; the average was about 50 percent.** This is the circuity factor applied to unit train shipments.

The fuel consumption factors developed as described above, adjusted to reflect relative circuity, are summarized in Table III-4. In Table III-5 the mileages for inland gathering of grain, coal and iron ore, and for inland shipments of iron ore from unloading port to point of consumption are presented.

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* A Preliminary Report by the Secretary of Transportation, The Prospects for Change in the Freight Railroad Industry, 1978.

** S. E. Eastman, Fuel Efficiency in Freight Transportation, 1980.

TABLE III-4
Summary of Fuel Consumption Factors

Mode	Ton-Miles/Gallon (Based on Actual Distance Traveled)	Circuity Factor	Adjusted Ton-Miles/Gallon	Distance Basis
Rail-single car	198	1.273	156	Highway dista
Rail-unit train	442	1.5	295	Highway dista
Truck	130	1.0	130	Highway dista
Barge (Chicago-New Orleans)	600	1.0	600	Waterway dist
Barge (Minneapolis-New Orleans)	528	1.0	528	Waterway dist

TABLE III-5
Overland Mileages

Commodity	Route	Mode	Percent	Miles	Comment
Coal	Ex Conneaut/Ashtabula	R	100	230	W. Va., Ohio, Pa. mines
	Ex Toledo/Sandusky	R	100	300	W. Va., Ohio mines
	Ex L. Michigan ports	R	100	250	S. Ill. mines
	Ex L. Superior ports	R	100	900	Wyoming mines
Iron ore	Ex L. Superior ports	R	100	100	e.g. Hibbing (Minn.)-Duluth
	Ex St. Lawrence ports	R	100	200	
	To Huron	R	100	150	Pittsburgh mills
	To Toledo	R	100	220	Ashland, Ky. mills
	To Ashtabula/Conneaut	R	100	150	Pittsburgh mills
Grain	Ex Duluth	R	50	600	
	Ex Chicago/Milwaukee	R	20	175	
		T	80	175	
	Ex Toledo	T	100	125	
	Ex Saginaw	T	100	125	

2. Deep-Draft Water Transportation

(1) Lake Vessels

A previous report of this study* identified the average ship class for each major commodity group transiting each lock system, as summarized in Table III-6. The characteristics of the ships in each class are shown in Table III-7, and the characteristics of the average ships used for the analysis of fuel consumption are shown in Table III-8.

TABLE III-6
Average Ship Class (1980)

Lock	Ore	Grain	Coal	Other Bulk	General Cargo
Soo	6.1	6.3	5.5	6.6	-
Welland	5.6	5.8	5.7	5.8	5.5
St. Lawrence	6.1	5.6	-	5.4	5.4

* Great Lakes/St. Lawrence Fleet Mix, March 1981.

TABLE III-7
Average Ship Characteristics

Vessel Class	Maximum Capacity at 25.5 Foot Draft (ST)	Mean Speed (mph)
5*	21,000	13.9
6**	15,000	14.7
7	27,000	14.7

* Includes lakers of Classes 5 and 6.
** Oceangoing vessels.

(2) Oceangoing General Cargo Vessels

Fuel consumption rates were estimated for ocean vessels which would be used to move cargo into and out of the Great Lakes area via other coastal ranges in the event the Great Lakes system reached capacity. Characteristics of these vessels are shown in Table III-9.

(3) Oceangoing Bulk Vessels

As in the case of oceangoing general cargo vessels, these vessels would carry Great Lakes cargo via other coastal ranges if the system reached capacity. Table III-10 provides relevant bulk vessel characteristics. The resulting fuel consumption factors (ton-miles per gallon) are plotted in Figure III-1. The relationship between fuel consumption and cargo capacity shown in the figure was used to develop the fuel consumption rates shown in Table III-11.

TABLE III-8
Great Lakes Vessel Characteristics

	Cargo Capacity (ST)	Mean Speed (mph)	Percent Utilization	HP	Ton-Miles/Gallon
Iron Ore	24,000	14.4	50	5,000	700
Coal and Other Bulk	15,000	14.7	60	4,000	670
General Cargo	15,000	14.7	60	4,000	670
Grain (oceangoing)	25,000*	14.4	60*	11,500	380
Grain (laker)	20,000	14.4	60	5,000	700

Note: Assumes fuel consumption rate of 1.18 gallons/HP-day.

*Overall utilization is 60 percent. Utilization is as follows:

- Lakes to St. Lawrence: 67 percent (loaded light)
- St. Lawrence to Overseas: 100 percent (topped off)
- Backhaul: 30 percent.

Source: Great Lakes Bulk Vessel Operating Costs, U.S. Maritime Administration.

TABLE III-9
Vessel Characteristics for
Oceangoing General Cargo Vessels

Commodity	Cargo Capacity (ST)	Average Speed (Knots)	Percent Utilization	Horsepower	Fuel Consumption Rate (gal/HP-day)	Ton-Miles/Gall
Other General Cargo	17,000*	20	75	17,000	1.18	305
Steel	30,000	15	65	10,000	1.18	593

*A 1,700 TEU vessel, averaging 10 ST per TEU.
**Nautical miles.

Source: U.S. Department of Energy, An Energy Study of the Marine Transportation Industry, 1978.

TABLE III-10
Characteristics of Oceangoing Bulk Vessels

Cargo Capacity (DWT)	Fuel Rate at Sea (Barrels per day)	Ton-Miles/Gallon
25,000	300	381
35,000	330	485
50,000	340	672
60,000	432	634
80,000	459	797
100,000	590	774

Source: U.S. Maritime Administration, Bulk Vessel Operation Costs.

Note: Speed is 16 knots, 50 percent utilization.

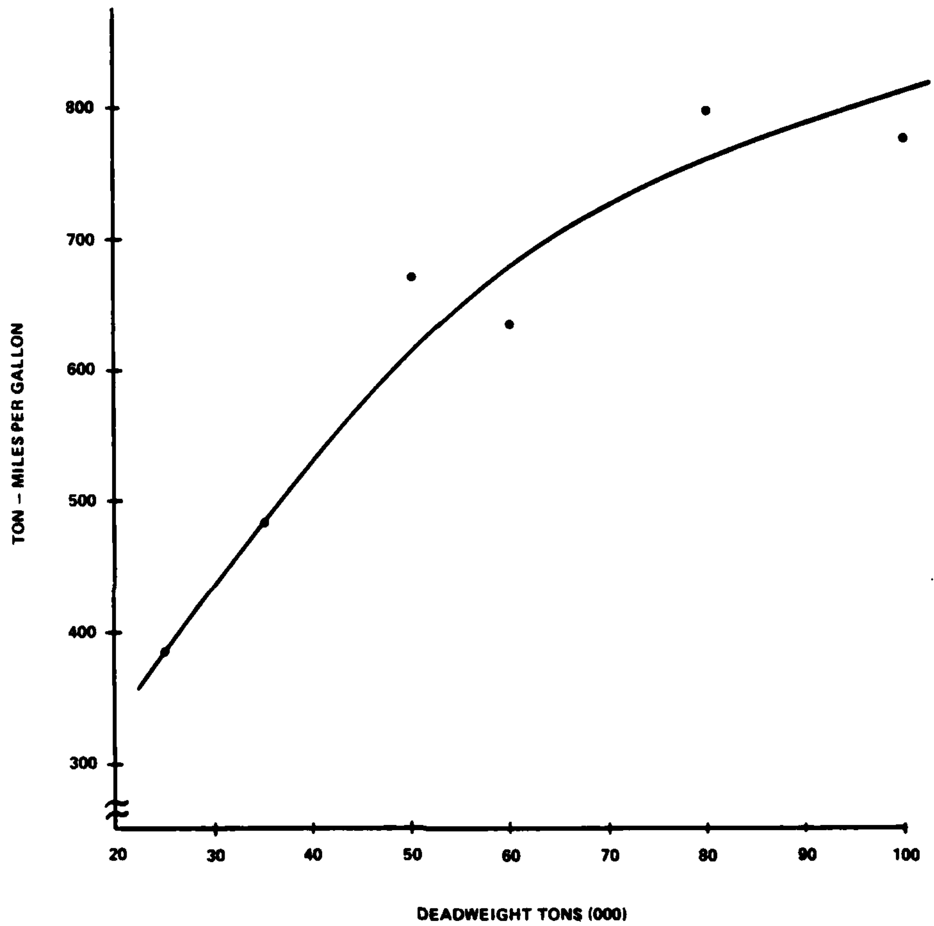
TABLE III-11
Fuel Consumption Rates for Oceangoing Bulk Vessels

Port	Commodity	Cargo Capacity(ST)	Tons-Miles/Gallon
Montreal	Grain	50,000	620
New Orleans	Grain	75,000	740
Baltimore	Grain Iron ore Other bulk	25,000	380

Note: Vessel size is based on spot charters at each port as reported in Drewry's Shipping Statistics and Economics.

Source: See Table III-10.

FIGURE III-1
Fuel Consumption - Deadweight Relationship



Source: Data contained in Table III-10.

2. RESULTS

Table III-12 summarizes the energy savings associated with non-structural improvements to maximum utility. Annual energy savings for the upper lock system are 1,900 billion Btus* by 2010 and increase to 5,700 billion Btus by 2020. Most of the energy savings are attributable to iron ore. Grain exported from Duluth via the Great Lakes requires more energy than via barge to New Orleans and subsequent export from that port in larger bulk carriers; this energy "penalty" is 130 billion Btus in 2010 and 430 billion Btus by 2020.

Non-structural improvements at the lower lock system also produce an energy penalty between 1990 and 2010 due to the fact that grain at Chicago and Milwaukee can be exported via barge through New Orleans using less energy than via the Great Lakes. This net energy penalty is 1,400 billion Btus in 1990 and 1,800 billion Btus in 2000. In the year 2000, grain exports from Duluth, Chicago and Milwaukee (barge-susceptible) comprise 20 percent of grain exports through the lower locks, and the energy "penalty" associated with these movements is greater than the energy savings resulting from the remaining movements. By 2010, however, barge-susceptible grain exports will comprise only 11 percent of total exports, so there is a net energy savings of 270 billion Btus in 2010, increasing to 122 trillion Btus by 2030.

The energy savings associated with structural improvement scenario no.1 (1350 x 115 foot locks) are shown in Table III-13. Energy savings at both lock systems are more significant. At the upper lock system the energy savings are 970 billion Btus in 2020, increasing to 18 trillion Btus by 2050. At the lower lock system, energy savings are 130 billion Btus in 2000, increasing to 1.1 trillion Btus by 2020 and 5.8 trillion Btus by 2050. The energy savings resulting from other lock improvement programs are provided in Appendix A.

Figure III-2 through III-6 illustrates the total energy savings for each of the five structural scenarios (consisting of non-structural improvements to maximum utility as well as structural improvements). The distribution of energy savings by commodity (as shown in the preceding tables for scenario no. 1) is similar for all of the improvement scenarios because the commodity mix at each lock system is the same. The greatest energy savings are produced by scenario nos. 1 and 2 since these scenarios allow the greatest amount of additional tonnage through the improved lock systems.

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* One billion Btus corresponds to about 170 barrels of oil. An annual energy saving of 1,900 billion Btus, therefore, is about 323,000 barrels of oil.

TABLE III-12
Energy Savings for Non-Structural Improvements
to Maximum Utility
(Billion Btus)

	1985	1990	2000	2010	2020	2030	2040	2050
UPPER LOCK SYSTEM								
Iron ore	0	0	0	1,700	5,400	5,400	5,400	5,400
Coal	0	0	0	140	110	110	110	110
Grain	0	0	0	(130)	(430)	(430)	(430)	(430)
Stone	0	0	0	47	160	160	160	160
Other bulk	0	0	0	150	490	490	490	490
	0	0	0	1,907	5,730	5,730	5,730	5,730
LOWER LOCK SYSTEM								
Iron ore	63	210	310	184	270	210	210	210
Grain	(110)	(2,400	(3,400)	(845)	(815)	(800)	(800)	(800)
Other bulk	23	62	100	93	210	270	270	270
General cargo	1,400	840	1,100	840	1,260	1,430	1,430	1,430
	1,376	(1,288)	(1,890)	272	925	1,110	1,110	1,110

TABLE III-13
Energy Savings for 1350 x 115 Foot Locks
(Billion Btus)

	2000	2010	2020	2030	2040	2050
UPPER LOCK SYSTEM						
Iron ore	0	0	910	5,800	11,000	16,000
Coal	0	0	19	130	250	380
Grain	0	0	(75)	(550)	(1,000)	(1,600)
Stone	0	0	28	190	380	590
Other bulk	0	0	87	600	1,200	2,000
			969	6,170	11,830	17,370
LOWER LOCK SYSTEM						
Iron ore	70	130	240	407	560	640
Grain	(170)	(16)	22	80	130	172
Other bulk	26	68	140	303	500	660
General cargo	210	700	680	2,510	4,300	5,500
	136	882	1,082	3,300	5,490	6,972

FIGURE III-2
Total Energy Savings for Structural Scenario No. 1
(Non-structural improvements to maximum utility and 1350' X 115' locks)

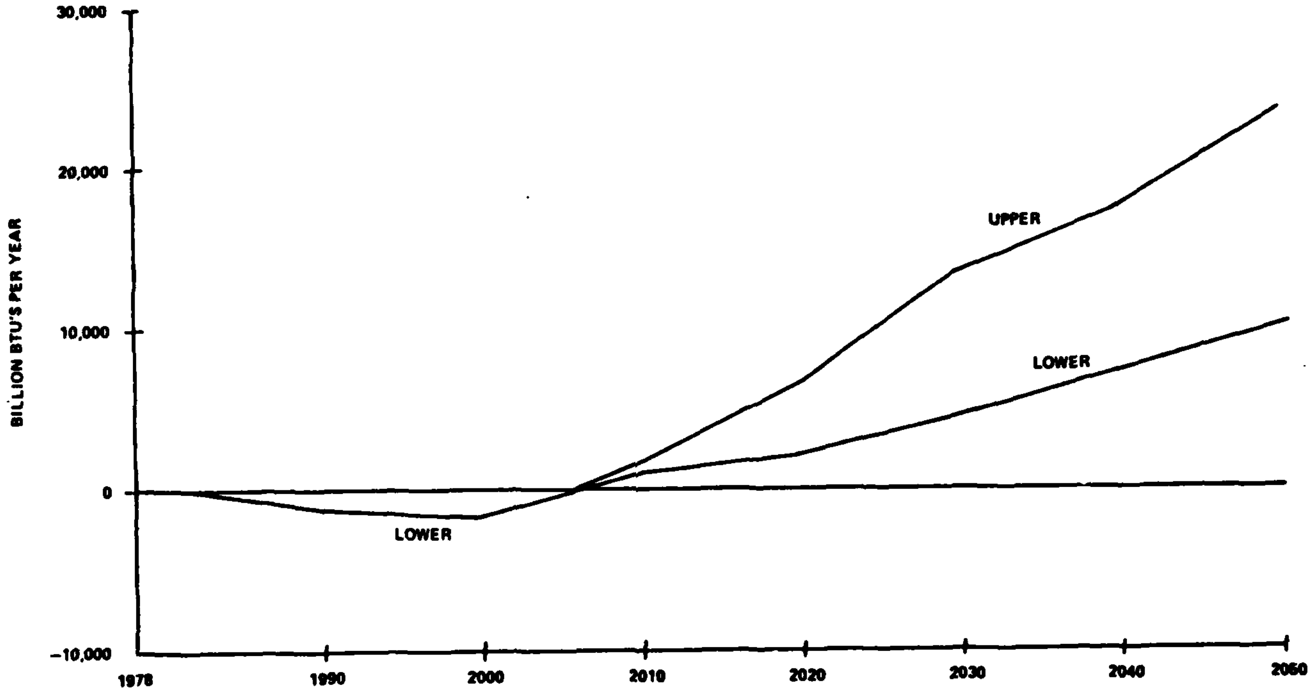


FIGURE III-3
Total Energy Savings for Structural Scenario No. 2
(Non-structural improvements to maximum utility and 1460' X 145' locks)

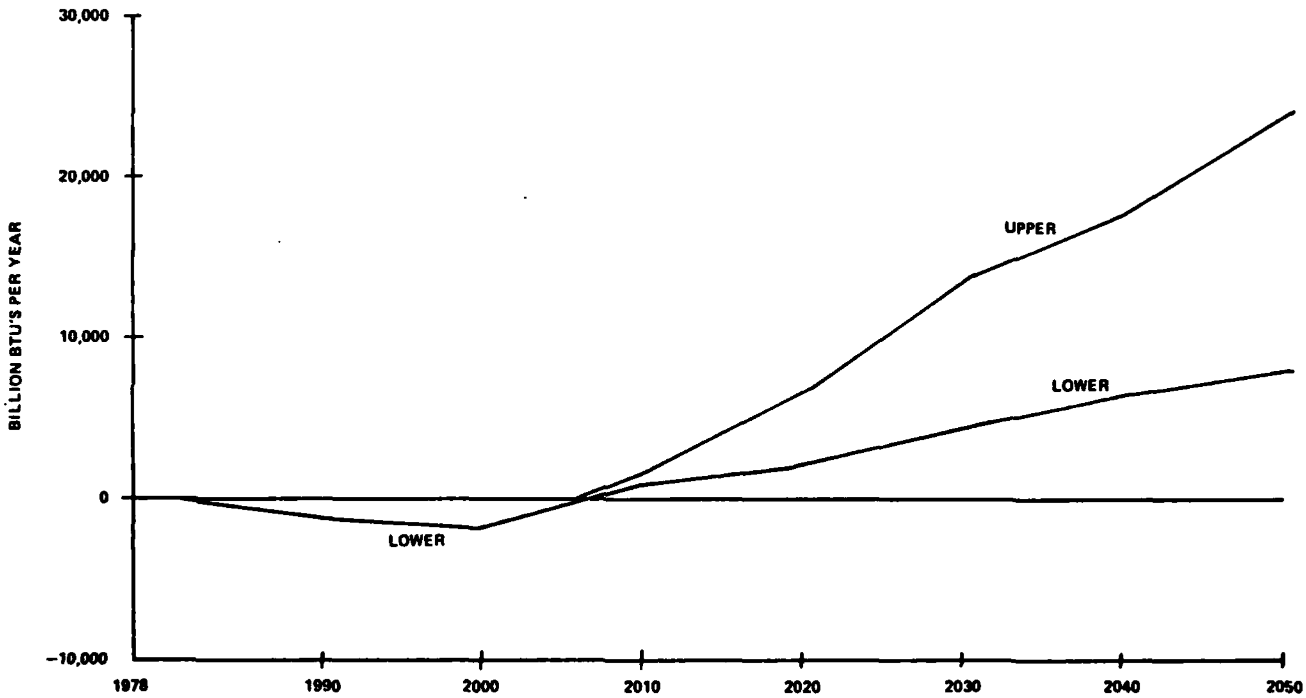


FIGURE III-4
Total Energy Savings for Structural Scenario No. 3
(Non-structural improvements to maximum utility and 28 foot draft)

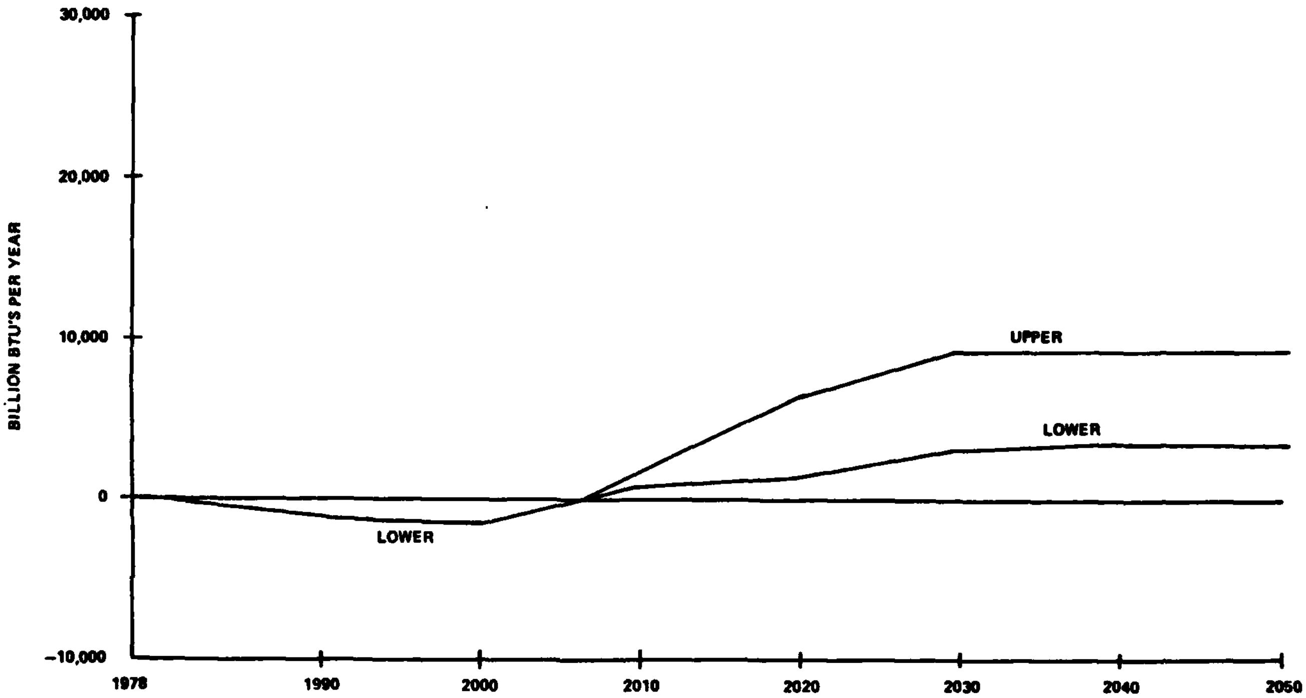


FIGURE III-5
Total Energy Savings for Structural Scenario No. 4
(Non-structural improvements to maximum utility and 32 foot draft)

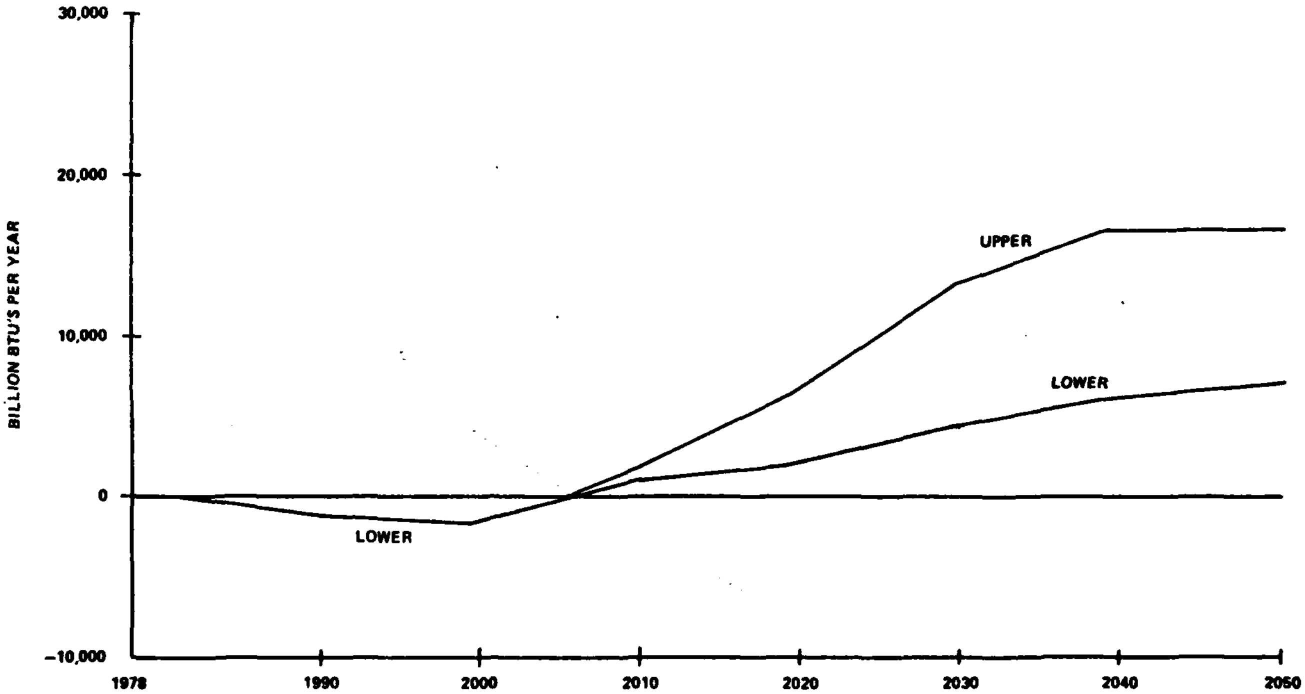
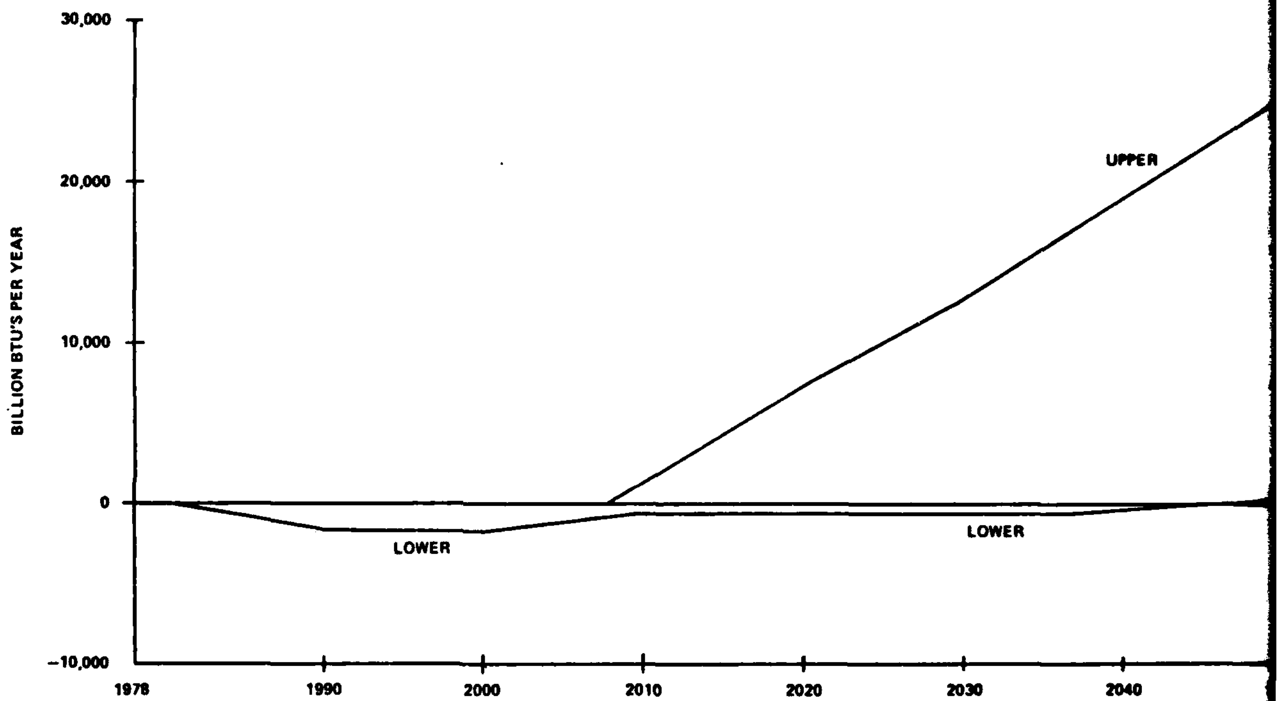


FIGURE III-6
Total Energy Savings for Structural Scenario No. 5
(Non-structural improvements to maximum utility, 1350' X 115' locks
and traffic constrained by the Welland Canal)



IV. POTENTIAL INDUCED INDUSTRIAL PRODUCTION DUE TO REDUCED FREIGHT RATES

This chapter addresses the extent to which reduced freight rates on the Great Lakes would induce higher regional production levels of grain, coal and steel. Table IV-1 shows the potential freight rate reductions which would result from structural lock system improvements. These rate reductions would be achieved because large ships could be used (if larger locks were built) or ships could be loaded with more cargo (if system draft were deepened). The maximum potential rate reduction is between 20 and 30 percent.

The discussion below examines the major factors influencing production of grain, coal and steel and the importance of lake transportation costs in the delivered prices of these products. The impact of a 20 percent lake rate reduction on production of these commodities is also analyzed.

1. THE GRAIN INDUSTRY

(1) The Great Lakes/St. Lawrence Seaway Handles Less Than 15 Percent of the Total Export Shipments of U.S. Wheat and Corn

About 80 percent of U.S. grain moving in the Great Lakes/St. Lawrence Seaway is exported. Corn and wheat exports account for 80 percent of these shipments. Therefore, the discussion will focus on corn and wheat exports as that segment of the grain industry that would be affected the most by reduced freight rates on the Great Lakes.

Table IV-2 shows that in 1977, 12 percent of total U.S. corn exports and 19 percent of total U.S. wheat exports moved through Great Lakes ports. These percentages were about the same in 1978, with 12.5 percent of corn exports and 21.5 percent of wheat exports moving through the Great Lakes. The major port region for export of these grains is the Gulf Coast, which in 1977 handled 57 percent of all U.S. corn and wheat export traffic.

TABLE IV-1
Potential Freight Rate Reductions

Commodity	Lock	Current Locks 26 Foot Draft Vessel Class	Current Locks 26 Foot Draft RFR ($/Ton)	Current Locks 28-32 Foot Draft Vessel Class	Current Locks 28-32 Foot Draft RFR ($/Ton)	1460 X 145 Ft Locks 26 Foot Draft Vessel Class	1460 X 145 Ft Locks 26 Foot Draft RFR ($/Ton)	Potential RFR Reduction (Percent)
Iron Ore	SOO	8.3	5.18	8.8	4.15	10.2	3.79	20-27
Grain	SOO	6.6	13.35	6.6	13.35	9.8	9.47	29
Iron Ore	SLR	6.7	6.20	6.7	6.20	9.8	4.35	30
Grain	SLR	6.6	11.88	6.6	11.88	9.8	8.43	29
Coal	SOO	7.9	4.84	7.9	4.84	9.5	3.70	23

Note: RFR is required freight rate, which is the freight rate which must be charged to cover all vessel capital and operating costs.

TABLE IV-2
U.S. Corn and Wheat Exports by
U.S. Port Area, 1977
(In Millions of Bushels)

		EXPORTS BY U.S. PORT AREA							
		Great Lakes		Atlantic Region		Gulf Region		Pacific Region	
Grain	Total U.S.	Bushels	Percent of Total	Bushels	Percent of Total	Bushels	Percent of Total	Bushels	Percent of Total
Corn	1,739	213	12	383	22	1,116	64	27	2
Wheat	1,076	198	19	37	3	504	47	337	31
Total	2,815	411	15	420	15	1,620	57	364	13

Source: Corn Movements in the United States and Wheat Movements in the United States, Interregional Flow Patterns and Transportation Requirements in 1977, by Mack N. Leath, D. Hill Lowell, and Stephen W. Fuller, January 1981.

(2) Fluctuations in Grain Transportation Costs Are Normal and Do Not Appear To Affect Export Levels

During the navigation season, the Seaway represents the least-cost distribution channel to Northern and Southern Europe for export corn and wheat grown in the Seaway hinterland of Montana, the Dakotas, Minnesota, Illinois, Michigan and Ohio. However, the following potentially competitive routes exist for this traffic:

- Rail movement from country elevator to Minneapolis terminals or terminals on the Illinois Waterway and then rail or barge movement to Gulf ports for transshipment to ocean vessels

- Rail movement directly to Atlantic Coast or Pacific Coast ports.

These routes are used for the winter movement of corn and wheat from the Seaway System hinterland.

The predominance of grain flows down the Mississippi River System for export at the Gulf exists in spite of competitively low freight rates through the Great Lakes which sometimes depress the costs of competing modes and distribution channels. In 1980, for example, the freight rate for bulk P.L. 480 grains from Mississippi River ports to foreign destinations during the Great Lakes season ranged from $119 to $136 per ton. In December, when the Great Lakes season ended, similar movements cost $142 to $160 per ton. There is no evidence to indicate that lower freight rates during the Great Lakes season induce new production, nor that higher freight rates during the off-season in the Great Lakes curtail production or restrict the movement of this grain.

In addition, the toll level on the St. Lawrence Seaway was increased about 100 percent between 1977 and 1980. Great Lakes corn and wheat exports for this period are shown in Table IV-3. Corn exports increased steadily through 1979; wheat exports have declined since 1978. Other factors may have contributed to the wheat decline, however. These include a prolonged dock strike in Duluth in 1979 and the Soviet grain embargo in 1980 (wheat is the principal grain exported to the Soviet Union).

TABLE IV-3
Great Lakes Wheat and Corn Exports
(Thousands of Tons)

Year	Wheat	Corn	Total GL
1977	5,940	5,964	11,904
1978	6,158	6,725	12,883
1979	4,446	8,020	12,466
1980	3,591	5,499	9,090

Sources: Waterborne Commerce of the United States, U.S. Army Corps of Engineers. Outlook and Situation Series for Corn and Wheat, U.S. Department of Agriculture, November 1981.

The data seem to indicate that grain exports are insensitive to transport costs so that increases or reductions of freight costs appear to have litle, if any, impact on production levels.

(3) Several Factors Influence Production Levels of Wheat and Corn

Demand for agricultural products is generally regarded as price-inelastic. Growing world demand should mean healthy and growing markets for the nation's farm products. The United States and Canada, the first and second leading exporters of wheat, respectively, supply over 65 percent of the free world's trade in that grain. Since wheat is one of the two primary food grains (the other is rice), the future trend in U.S. exports will be determined largely by the nutritional needs of the world's growing population.

Corn has been one of the nation's fastest growing export commodities. This dramatic growth has resulted in a surge in demand for feed grains, and corn in particular, in the developed countries of Western Europe. The two elements which have combined to create this growth are an increase in European meat consumption and inadequate local quantities of feed for European meat and poultry producers.

Thus, while food grain, including wheat, is a staple of the less developed nations, feed grain consumption is concentrated almost entirely in the developed countries. Therefore, the economic, political and geographical relationships among leading exporting and importing regions of the world are a primary factor in levels of production of U.S. wheat and corn.

Other production factors include the following:

- Federal regulatory policy and the price support system
- Management of international trade by the Federal Government
- Increasing costs of production due to rising energy prices and land values
- Technological advances, such as in irrigation methods
- Declining water tables
- Increased farm specialization and economies of scale.

In the grain industry, the cost of transportation is regarded as a factor of marketing, not of production. A change in the cost of transportation mode affects the decision to sell domestically or to export. Grain pricing and marketing mechanisms are extremely complex, and profit margins are very narrow. Fluctuations in supply stocks and demand and slight shifts in transportation costs at a given point in time often result in frequent changes in distribution channels to the most profitable shipping pattern. Selection of the most profitable shipping pattern does not affect the level of grain production.

(4) <u>A Reduction in Great Lakes/St. Lawrence Seaway Freight Rates for Export Grains Would Not Appear To Affect U.S. Levels of Production</u>

The cost components of the 1980 delivered prices of wheat and corn exported through the Great Lakes are presented in Table IV-4. The grain industry is capital-intensive, with machinery and land responsible for about 50 percent of total delivered costs. The cost of water transportation of export wheat and corn ranges from 10 to 15 percent via the ports of Duluth and Toledo, respectively.

TABLE IV-4
Breakdown of Delivered Price
of Wheat and Corn Exports, 1980[1]

	Wheat		Corn	
	Dollars Per Ton	Percent of Total Cost	Dollars Per Ton	Percent of Total Cost
Production (Variable)				
Seed	8.00	3	5.36	3
Fertilizer	25.33	10	18.57	11
Lime	.67	< 1	.36	< 1
Chemicals	.33	< 1	6.07	4
Custom Operations	2.00	1	1.43	1
Labor	8.67	3	4.29	3
Fuel and Lubrication	7.67	3	4.64	3
Repairs	4.67	2	3.21	2
Drying	-	-	2.86	2
Miscellaneous	1.00	< 1	-	
Interest (variable)	3.67	1	2.14	1
(Fixed)				
Machinery (including replacement, interest, taxes and insurance)	26.00	10	16.43	10
Farm Overhead	6.33	3	2.86	2
Management	9.33	4	6.79	4
Land (composite, current value)	95.00	37	56.07	34
Total	198.67	78	131.08	81
Transportation				
Inland	29.62	12	7.14	4
Water (export)[2]	26.00	10	24.40	15
Total	55.62	22	31.54	19
Total	254.29	100	162.62	100

1 Cost components are for production in the lake states and corn belt.
2 Represents cost of exporting wheat via Duluth and corn via Toledo.

Source: Production costs--"Costs of Producing Selected Crops in the United States-1978, 1979, 1980 and Projections for 1981," Economics and Statistics Service, U.S. Deprtment of Agriculture. Transportation Costs-- Booz, Allen & Hamilton.

Table IV-5 presents a comparison of 1980 delivered export wheat and corn prices through the Seaway with prices reflecting a hypothetical 20 percent reduction in freight rates for the water route through the Great Lakes/St. Lawrence Seaway. The table shows that this reduction would result in only a 2 to 3 percent reduction in the delivered price of wheat and corn exports overseas. This represents an insignificant percent, but a significant dollar savings of about $5 per ton. However, as discussed earlier, demand for wheat and corn is relatively insensitive to price changes and it is highly doubtful that such a reduction in total prices would open new markets or increase existing demand.

2. THE COAL INDUSTRY

(1) Great Lakes Transportation of Coal Primarily Services Utility Plants in the Region

Between 1976 and 1979, domestic movements of coal on the Great Lakes exhibited a 13 percent increase for the 3-year period and accounted for more than 50 percent of total Great Lakes coal movements. Exports to Canada comprised almost all of the remaining shipments and fluctuated erratically during the same period. Table IV-6 identifies these movements for each year.

Virtually all of the coal moving on the Great Lakes is bituminous. Metallurgical coal is mined in the Appalachian region and moves by rail to midwestern steel mills.

In the United States, as well as in Canada, the primary markets for coal are the electric utilities and the iron and steel industry. The major use by far is for power generation in public utilities. Table IV-7 shows consumption of U.S. coal by the states surrounding the Great Lakes. In 1976, consumption by electric utilities accounted for 68 percent of total coal use in the region and, excluding New York and Pennsylvania, accounted for 73 percent of total consumption by the remaining states. The region accounted for almost 50 percent of total U.S. coal consumption and about 30 percent of the coal consumed to generate electricity.

TABLE IV-5
Comparison of Delivered Grain Price With
20 Percent Great Lakes Freight Rate Reduction

Cost Elements	Wheat ($/Ton) Current Delivered Costs	Wheat ($/Ton) Delivered Costs With GL Freight Rate Reduction	Corn ($/Ton) Current Delivered Costs	Corn ($/Ton) Delivered Costs With GL Freight Rate Reduction
Production	198.67	198.67	131.08	131.08
Inland Transportation	29.62	29.62	7.14	7.14
Water Transportation	26.00	20.80	24.40	19.52
Transportation Total	55.62	50.42	31.54	26.66
Total	254.29	249.09	162.62	157.74
Difference	5.20 (2%)		4.88 (3%)	

By 1985, consumption of coal in the same seven Great Lakes states is expected to increase about 3 to 4 percent per year. Most of the growth in shipments is expected to be for generation of electricity.*

Canadian destinations accounted for about 40 percent of the Great Lakes coal traffic in 1979, with the principal destinations being the steel center in Hamilton and the public utilities in Toronto. The vast majority of these shipments are loaded at U.S. Lake Erie ports.

(2) The Great Lakes Supplies Only About 11 Percent of Total Regional Utility Coal Consumption

As shown above, the majority of Great Lakes coal movements are deliveries of steam coal to U.S. electric utilities in the surrounding region. Most of these movements are controlled by eight utilities representing 19 power plants, of which the largest accounted for about 14,800,000 tons of coal in 1978.

* U.S. Department of Transportation, Rail Transportation, Requirements for Coal Movements in 1981, December 1978.

TABLE IV-6
Movements of Coal and Lignite on the Great Lakes
(thousand tons)

Year	Total	Total Percent Growth	Imports	Exports Canadian	Exports Overseas	Domestic	Domestic Percent Growth
1976	38,270	-	37	16,396	19	21,819	-
1977	39,517	3.3	19	16,880	-	22,618	3.7
1978	38,266	-3.2	-	14,972	-	23,294	3.0
1979	43,667	14.1	-	18,911	-	24,756	6.3

Source: Waterborne Commerce of the United States, various years, U.S. Army Corps of Engineers.

TABLE IV-7
U.S. Coal Consumption by the
Great Lakes States, 1976
(thousand tons)

	Types of Users				
State	Electric Utilities	Coke and Gas Plants	Retail Dealers	Others, Including Industrial	To
Ohio	50,130	12,505	692	7,637	70
Indiana	29,239	12,450	363	3,785	45
Illinois	35,011	2,735	537	3,172	41
Michigan	21,197	4,493	248	3,867	29
Wisconsin	10,978	268	308	2,017	13
Pennsylvania	37,249	23,281	192	3,870	64
New York	5,980	5,157	20	2,405	13
Total	189,784	60,889	2,360	26,753	279
Percent of Total	68	22	1	9	10
Total U.S.	454,861	84,783	4,017	52,623	596
Percent of U.S.	32	10	1	4	

Source: <u>Bituminous Coal and Lignite Distribution, Calendar Year 1976</u>, Bureau of Mines, Mineral Industry Survey.

These shipments represent about half of the coal loaded at ports in Lake Erie, as well as movements from the port of Duluth/Superior and limited shipments from Chicago to other Lake Michigan destinations.

Data in the previous tables indicate that coal shipped on the Great Lakes accounted for only 11 percent of the total coal consumed by electric utilities in the region. Most of the utilities in the region receive coal by rail. This is especially true for plants located at the southern end of the lakes.

(3) <u>A Number of Factors Will Influence the Future Level of Great Lakes Coal Shipments</u>

A reduction in Great Lakes freight rates might make coal more attractive than other fuels for generation of electricity. However, a number of other factors will also influence the choice of fuels. These factors include the following:

- Implementation of mandatory coal conversion programs
- The social and environmental acceptability of nuclear power
- Environmental regulations concerning coal combustion
- Implementation of the Federal coal land leasing program
- The development of commercially viable, competitively priced synthetic gas and liquid fuel from coal
- World oil prices
- Federal taxes and local royalties
- Rail transportation costs
- Coal storage facility development
- Investment in distribution facilities, especially port and rail.

Water transportation cost will be only one of several factors influencing future demand for coal.

(4) Reduced Great Lakes Freight Rates Will Not Cause a Significant Reduction in the Delivered Price of Coal

Table IV-8 identifies the cost components of the delivered price of eastern and western coal. Eastern coal is represented by underground mining of Kentucky and West Virginia coal; western coal is represented by surface mining of Montana coal. The delivered prices include transportation costs from mine to Great Lakes ports by rail and laker transport to Detroit. The table shows that for Appalachian coal the FOB mine price is 63 percent of the delivered price compared to 29 percent for western coal. The cost of transportation on the Great Lakes is only 5 percent of the delivered price for Appalachian coal and 21 percent for western coal.

As coal is generally sold FOB mine, changes in distribution rates have a direct impact on the delivered price to the customer. A 20 percent reduction in Great Lakes freight rates would cause only a 1 percent reduction in the delivered price of Appalachian coal but a 4 percent reduction in the delivered price of western coal.

It is anticipated that the lock improvements required to reduce transportation costs by this amount would take several years to complete. Since the mine price of coal has increased substantially in the last 5 years, the 1 to 4 percent reduction in the delivered price of coal would not appear to be significant enough to cause an increase in Great Lakes coal shipments.

3. THE STEEL INDUSTRY

(1) Iron Ore Supply and Steel Production Are Concentrated in the Great Lakes Region, Where the Lakes Are Essential for Iron Ore Transportation

In 1979, 96.2 million tons of iron ore moved on the Great Lakes in U.S. trade. Of this total, 84.2 million tons were produced in U.S. mines; 78.5 million tons were for domestic use and 5.7 million tons were exported to Canada. U.S. steel mills imported about 12 million tons of Canadian ore.

Most of the iron ore movements on the Great Lakes are destined for U.S. and Canadian steel plants in the region. About 70 percent of American steel capacity and production is located on or around Lake Erie and

TABLE IV-8
Components of 1980 Delivered
Coal Prices

Cost Element	Ky./W. Va. Coal via Toledo to Detroit '80 $/Ton	Ky./W. Va. Coal via Toledo to Detroit % of Total	Montana Coal via Duluth to Detroit '80 $/Ton	Montana Coal via Duluth to Detroit % of Total
Annualized cost	8.88	23	1.87	10
Labor	9.84	26	1.20	6
Supplies and power	4.32	11	.77	4
Other	.96	3	1.65	9
Total FOB mine price	24.00	63	5.49	29
Inland Transportation	12.20	32	9.51	50
Water Transportation	1.80	5	4.00	21
Total transportation cost	14.00	37	13.51	71
Total delivered price	38.00	100	19.00	100

Sources:

- Mine prices: Pennsylvania State University, Coal Industry Problems, prepared for Electric Power Research Institute, March 1981.
- Transportation: Booz, Allen and Hamilton.

Chicago, Cincinnati and Pittsburgh. This includes more than 90 U.S. steel plants with annual steel producing capabilities of about 130 million tons. Canada has three significant steel plant locations in the Great Lakes: Hamilton, Nanticoke and Sault Ste. Marie. The current annual capacity of these facilities is about 14 million tons.

The ore requirement for the Great Lakes region steel mills is supplied by two primary source areas. The most significant source is the Lake Superior district. Ore production in this area is concentrated along the Laurentian continental divide, with the primary sources found in the Mesabi range in northern Minnesota and the Steep Rock region in western Ontario. Additional ore is produced from mines in Michigan's Upper Peninsula and in Ontario's Michipicoten and Sudbury districts along the eastern shore of Lake Superior. The other major source for the region's steel market is the Quebec-Labrador range north of Sept Isles on the Gulf of St. Lawrence. Most of this production is beneficiated ores, especially high-grade pellets. In addition, there are several small mines in other locations within the Great Lakes area, and a very small quantity of ore is imported into the region from Brazil, Liberia and Venezuela.

Table IV-9 shows receipts and consumption of iron ore at U.S. iron and steel plants from Great Lakes ore-producing areas from 1976 to 1979. The table illustrates that U.S. steel mills in the region receive their major supplies of iron ore from local production areas.

The location of the consuming mill plays an important part in determining the iron ore transportation requirement. Distance factors make Superior and Quebec/Labrador ores quite competitive in the areas bordering Lake Erie. Another important factor in determining supply points is the lakeside location of many ore-consuming mills in the region, such as those in Chicago, Gary, Detroit, Cleveland, Hamilton and Buffalo. More than 50 percent of the steel furnaces in the Great Lakes market and all Canadian production facilities are located at lakeside.

Thus, almost all shipments of iron ore and agglomerates are shipped to area steel mills from the mine by rail to Great Lakes loading ports where they are carried by vessel to the mills. This movement is usually the least-cost route of transport. Interior

TABLE IV-9
Receipts and Consumption of Iron Ore at U.S. Iron and Steel Plants
(in thousand tons)

	Iron Ore Originating Area					
	United States		Canadian		Foreign	
Year	Great Lakes	Other	Great Lakes	Other	Ores	Total
Receipts						
1976	63,823	11,598	4,512	19,098	18,666	117,697
1977	44,500	13,167	4,212	18,519	14,546	94,944
1978	70,253	9,419	3,103	16,050	15,402	114,227
1979	71,885	9,812	1,717	19,761	12,717	115,892
Consumption						
1976	63,864	11,267	4,672	18,185	16,335	114,323
1977	57,663	13,217	4,457	16,985	16,140	108,462
1978	64,617	10,070	3,379	18,734	19,484	116,304
1979	66,080	9,872	2,228	20,843	15,991	115,014

Source: Iron Ore, 1980, American Iron Ore Association.

steel mills in the area are generally older facilities, and as the distance from the Great Lakes/St. Lawrence Seaway increases, the attractiveness of lakes-transported ores diminishes in favor of ores delivered by other modal combinations. These facilities include Youngstown, Cincinnati and Pittsburgh area plants. In these instances, all-rail shipments are often economically attractive. Therefore, the Great Lakes system appears to have a captive position in the transport of iron ore to many of the iron and steel plants within the region.

A stabilizing factor in the sourcing and water distribution of iron ore is the proprietary ownership of mines and Great Lakes vessels by the steel companies. Most of the iron mines are owned individually, jointly, or in consortia by steel companies. U.S. Steel alone owns over 20 percent of the iron ore capacity in the Lake Superior ranges. Of 140 U.S. bulk carriers transporting ore that operate on the Great Lakes, almost 40 percent are owned by U.S. steel companies.

(2) <u>The Transportation Cost of Raw Materials Such as Iron Ore Does Not Have a Significant Impact on U.S. Production Levels of Steel</u>

No definite trend is indicated in the long-run per capita demand patterns for iron and steel in the United States. Rather, consumption of steel is correlated with business cycles and national economic conditions. Production peaks occur in expansionary periods and have reached as high as 1,000 pounds per person; production troughs in recessionary climates have dropped as low as 675 pounds per capita.

Another commodity, foreign steel imports, greatly influences the production of the domestic iron and steel industry and, ultimately, relates to the demand for steel mill products in the United States and Canada. Table IV-10 shows shipments and supplies of the U.S. steel industry from 1976 to 1979 and indicates the relationship of steel imports to apparent steel supply.

Other factors seriously affecting the levels of U.S. steel production include:

- Federal tax and regulatory policy for business and fixed investment

TABLE IV-10
The U.S. Iron and Steel Industry
Shipments and Supply
(in thousand tons)

	Steel Mill Products					
Year	Total Net Shipments	Less Exports	Plus Imports	Apparent Steel Supply	Imports as Percent of Supply	U.S. as Percent of World Production
1976	89,447	2,654	14,285	101,078	14.1	17.2
1977	91,147	2,003	19,307	108,451	17.8	16.9
1978	97,735	2,422	21,135	116,648	18.1	17.3
1979	100,272	2,818	17,518	114,962	15.2	16.5

Source: Annual Statistical Report, American Iron and Steel Institute, 1979.

- Development and use of steel substitutes
- Environmental regulation and enforcement.

Internally, the most serious barrier to production increases by the steel industry is the requirement for large capital investment. The major uses of funds include capacity maintenance, pollution control and capacity expansion, and these costs are steadily increasing. Low stock prices eliminate the possibilities of new equity, and debt-equity ratios limit new borrowing.

The issues identified above are major concerns for the domestic steel industry. Reasonable changes in the cost of transporting raw materials such as iron ore are only one of many factors influencing steel production.

(3) <u>A 20 Percent Reduction in the Cost of Transporting Iron Ore on the Great Lakes Would Result in an Insignificant Reduction in the Price of Steel</u>

Table IV-11 identifies the component costs of steel production. By far the largest cost is labor, which represented 33 percent of the price of steel in 1980. Energy is also a major contributor to steel prices and accounted for 10 percent of the 1980 price. Iron ore is the most significant raw material cost (which includes the transport in cost) and was responsible for 13 percent of the price of steel in 1980.

The component costs of the delivered price of iron ore are shown in Table IV-12 for one ton of iron ore moving from Lake Superior through the Port of Duluth to Cleveland. These figures indicate that the FOB mine price is 73 percent of the delivered price, while the cost of transportation is only 27 percent of the delivered price. The costs of rail and water movement are 13 to 14 percent.

A 20 percent reduction in Great Lakes freight rates would result in a decrease in the delivered price of iron ore of $1.19 or a decrease of 2.5 percent. This would cause a drop in the price of steel of 0.2 percent.

TABLE IV-11
Component Costs of the Price of Steel, 1980
(per ton)

Cost Element	$/Net Ton	Percent of Delivered Price
Labor	$171.82	33
Materials		
Iron ore	68.64	13
Coal and coke	56.06	11
Scrap	11.59	2
Fluxes	26.98	5
Refractories	15.14	3
Miscellaneous	60.43	12
Energy	51.71	10
Financial expenses	34.14	7
Total pre-tax cost	496.51	96
Taxes and profit	22.55	4
Total cost	519.06	100

Note: At standardized production rate of 90 percent.

Source: World Steel Dynamics for 1980.

TABLE IV-12
Component Costs of Delivered Price of Iron Ore, 1980
(per ton)

Cost Element	$/Net Ton	Percent of Delivered Price
FOB mine price	$33.94	73
Inland transportation	6.54	14
Water transportation*	5.93	13
Total transportation	12.47	27
Total delivered price	46.41	100

*Represents movement of iron ore from the Port of Duluth to Cleveland.

Source: Booz, Allen & Hamilton Inc.

Not only is this a relatively insignificant reduction in price, but it is highly doubtful that such a minor cost reduction in iron ore would be passed on to the consumer. Additionally, since 1974 iron ore costs have increased at an annual rate of nearly 10 percent because of large increases in energy and labor costs, a decline in the quality of ore being obtained, and sharply higher costs for capital equipment. Future increases in the costs of labor, energy and capital equipment will probably more than offset any potential steel price reductions due to decreased delivery costs of iron ore.

V. REGIONAL ECONOMIC IMPACTS

This chapter identifies the regional economic impacts of lock improvement programs. This chapter contains three sections:

- Identification of regional economic impact factors
- Identification of port cargo traffic affected by lock improvement programs
- Expected port economic impact.

These sections are presented below.

1. IDENTIFICATION OF REGIONAL ECONOMIC IMPACT FACTORS

Port activity generates tangible business activity for firms which participate in the transfer of cargo between ship and port, and which provide support services for ships while in port. In this study, port economic impact is measured in terms of income and employment. These two parameters are related by the wages of the sectors participating in port activity.

Gross revenue is often used as a measure of economic impact. This concept is difficult to regionalize because payments made related to port activity are only partially in return for goods and services provided by the regional economy. For example:

- Payments to stevedoring firms offset the cost of labor and equipment. The portion attributable to equipment costs is ultimately passed on to equipment manufacturers, which are frequently not located in the local community.
- Railroad freight revenues often cover the entire line haul, as well as local railroad services such as dumping and switching.
- Most of a ship's bunkering expense covers the cost of the fuel, which usually originates beyond the port area.

In addition, most of the Great Lakes bulk traffic is handled at private docks, and revenue is not reported publicly and may not be accounted for separately by the firm operating the dock.

Per-ton factors for income and employment are provided in Table V-1. These factors were developed in a comprehensive study for the Port of Baltimore, which involved a mail and telephone survey of almost 100 percent of the largest firms participating in port activity in Baltimore. The survey identified the number and average income of employees directly related to port activity. It is felt that this approach produced a realistic estimate of port economic impact since such an extensive enumeration of port participants was successful in identifying all major sources of port income and employment.

TABLE V-1
Port Economic Impact Factors

	Employment (Jobs per million tons per year)		Income (Dollars per ton)	
	Bulk Cargo	General Cargo	Bulk Cargo	General Cargo
Marine Terminal Employees and Longshore Labor	34	1001	0.95	20.35
Agents and Brokers	3	180	0.08	3.24
Freight Forwarders and Customhouse Brokers	--	131	--	5.10
Local Service Industries and Government Workers	19	107	0.38	2.68
Miscellaneous	4	31	0.09	0.63
	60	1450	1.50	32.00

Source: Booz, Allen & Hamilton, Economic Impact of the Port of Baltimore (draft), 1981.

The data in the table reflect employment in the following sectors:

- Marine terminal employees
- Tugs and pilots
- Longshore labor (if applicable)
- Agents (if applicable)
- Railroad terminal employees
- Ship chandlers
- Freight forwarders and warehousemen
- Banking and insurance.

2. IDENTIFICATION OF PORT CARGO TRAFFIC AFFECTED BY LOCK IMPROVEMENT PROGRAMS

Appendix B contains a listing of the annual cargo traffic for each major U.S. port in the Great Lakes system which would be affected by lock system improvements. The tables identify tonnage which is able to use the system because larger locks (1350 x 115 foot locks) are installed. This scenario involves the following improvements:

	Lock System	Year
Non-structural alternatives to maximum utility	Soo	2006
	Welland	1981
	St. Lawrence	1996
1350 by 115 foot locks	Soo	2018
	Welland	1996
	St. Lawrence	1996
Capacity condition encountered	Soo	2050
	Welland	2034
	St. Lawrence	2048

The regional impacts of this lock improvement program are considered to be representative of the impacts resulting from a combination of non-structural and structural improvements.

Appendix B identifies the tonnage shipped (or received) by each port, regardless of whether the movement is U.S. domestic, Canadian or international trade, because port economic impacts are accrued regardless of the trade. Bulk cargo and general cargo are shown separately. The cargo forecasts are unconstrained in the sense that traffic using the Soo Locks and the Welland Canal which could not move through the Welland Canal after 2034 is shown moving through the Soo Locks after 2034.

3. EXPECTED PORT ECONOMIC IMPACT

The results of the analysis are presented in a series of tables in Appendix B, which identify the following for each major U.S. Great Lakes port:

- Employment attributable to bulk cargo
- Employment attributable to general cargo
- Income attributable to bulk cargo
- Income attributable to general cargo.

These tables are summarized in Table V-2. This lock improvement program will protect almost 4400 port employment positions in 1985 which would be lost if additional traffic were not able to use the Great Lakes system. The employment impact increases to 7300 jobs in the year 2010 and 23,000 positions by 2050.

Direct income related to port activity protected by the improvement program amounts to $97 million in 1985, increasing to $164 million in 2010 and $547 million in 2050. Part of this income would be respent within the local economy. For this analysis it was assumed that for every one dollar of income earned in the port community, an additional 40 cents is generated as a result of purchases of locally produced goods and services.* This results in an income multiplier of 1.4.

Income including respending is also shown in Table V-2. Total income is expected to be $136 million in 1985, increasing to $230 million in 2010 and $766 million in 2050.

* Estimated by the Regional Income Multiplier System of the Bureau of Economic Analysis, U.S. Department of Commerce.

TABLE V-2
Summary of Regional Economic Impact
(1350 X 115 Foot Locks)

	1985	1990	2000	2010	2030	2050
Employment (number of jobs)						
Bulk cargo	163	255	363	1,393	5,679	10,268
General cargo	4,228	2,079	2,911	5,933	10,660	13,213
	4,391	2,334	3,274	7,326	16,339	23,481
Direct Income ($ million)						
Bulk cargo	4	6	9	34	141	256
General cargo	93	45	64	130	235	291
	97	51	73	164	376	547
Total Income Including Respending ($ million)	136	71	102	230	526	766

Note: This table identifies potential losses unless a capacity condition is corrected.

VI. ENVIRONMENTAL AND SOCIAL IMPACTS

This chapter discusses the environmental and social impacts associated with Great Lakes/St. Lawrence Seaway lock system improvements, and is organized in five sections:

- Introduction
- Biological impacts
- Impacts on the physical environment
- Impacts on the quality of life
- Institutional interests.

These sections are presented below.

1. INTRODUCTION

Attention in recent years has been focused on environmental and social impacts resulting from planned improvements to the Great Lakes/St. Lawrence Seaway navigation system, particularly from the extension of the navigation season. More than half of the potential impacts that have been cited are related to vessel movement through ice and the ice booms, bubbler systems, and other technologies that have been recommended to permit winter navigation in ice conditions. Lock system improvements to increase annual traffic capacity would not involve this equipment. Consequently, potential environmental and social impacts resulting from lock system improvements would occur only with dredging and lock construction, increased vessel traffic, and the movement of larger vessels through these waterways.

Concerns acknowledged by Great Lakes area associations include the following:

- Threat of accidents involving tanker vessels and vessels carrying potentially hazardous materials
- Disturbances caused by vessel transit in shallow waters and restricted channels
- Discharge of salt water ballast and possible introduction of foreign species into the Great Lakes, resulting in disruption to the ecology system and a risk to public health.

Environmental and social issues have been identified by governmental bodies, individuals and organized groups representing wide interests including:

- Recreation
- Business
- Conservation
- Industry
- Fish and wildlife
- Professional
- Educational
- Utility
- Labor
- Community.

This chapter identifies and briefly describes a variety of potential environmental and social impacts that could result from lock system improvements, and is based on a review of relevant studies and reports dealing with this subject. Potential impacts have been screened for their relevance to improvements to lock systems and are discussed in the following sections of this chapter.

2. BIOLOGICAL IMPACTS

Dredging, construction, and increased vessel movement associated with improvements to the Great Lakes/St. Lawrence Seaway lock system will create some physical alteration of sediment in nearshore zones and connecting channels. Open deepwater areas would not be significantly affected. This sediment disruption and the development of disposal sites for dredge material could negatively affect fish, wildlife and plant organisms to some degree.

(1) Benthic Communities

Benthic communities are communities of organisms attached to or resting on the bottom or living in bottom sediments of rivers or lakes. The removal, disruption, suspension and resettling of sediment particulates will result in some disturbance and/or destruction of benthic communities in the project zone and to some degree downstream. Although much existing benthic life would be removed from the actual dredging sites, and some benthos may be destroyed downstream due to covering by settled-out sediment and silt, recolonization would probably soon reoccur by surviving organisms at disturbed sites and by benthic life drifting into disturbed bottom areas over time.

(2) Aquatic and Terrestrial Vegetation

Dredging and construction of lock improvements would remove or adversely affect submerged vegetation in the vicinity of the locks. This impact could extend to aquatic organisms and fish due to the loss of habitats or the interruption of food chain production. Wetland areas within the relevant connecting channels, but at some distance from the locks, could be affected by ice movements associated with season extension.

Shore-based lock construction support facilities will have little impact on terrestrial vegetation. Disposal sites for dredged mate_ial would only temporarily affect vegetation as demonstrations have shown that normal plant life will soon thereafter reestablish itself.

(3) Fisheries

Project activities in the shallow waters of connecting channels may influence fish spawning, including egg survival, behavior, distribution of species and spawning, nursery and food/cover habitats in wetlands. Although fish spawning activities generally occur during the spring and early summer months, some impacts on the complex combination of physical, chemical, biological and social structures of the ecosystem could probably have a short- or long-term effect on river fisheries, particularly in the St. Lawrence and St. Mary's Rivers.

While fish migration could be affected by bubbler systems which would be used for navigation season extension, lock expansion would probably not cause a significant increased problem from that which exists under present lock conditions, unless construction were performed during a known fish migration period.

(4) Wildlife and Endangered Species

Most impacts to wildlife and endangered species that have been previously cited would result from the disturbance of ice formation and winter feeding areas in shoals, littoral zones and coastal wetlands of connecting channels, and would not be caused by a lock improvement project. To the extent that breeding habitats, especially in emergent wetlands, may be

adversely affected, nesting and rearing habitats for aquatic wildlife (i.e., fur bearer, waterfowl, amphibian, reptile) populations could be altered to some degree.

3. IMPACTS ON THE PHYSICAL ENVIRONMENT

Potential impacts to the physical environment include possible short-term/long-term degradation of the quality of air, water and shorelines of connecting channels. These impacts would result from:

- Increased levels of emissions to the atmosphere due to the increase in vessel traffic
- Dredging activities
- Dredge spoils disposal
- Introduction of foreign species and pollutant emissions to the lakes and rivers due to increased discharge of salt water ballast
- Amplified effects of navigation system hydraulics and sediment transport.

The effects of these activities on the physical environment are discussed in the following sections.

(1) Air Quality

Air pollutant emissions are released when a ship is under way, and also when a ship is dockside, as generally one or two boilers are operated when a ship is at berth. Increased vessel traffic will result in the increased discharge of gaseous effluents into the atmosphere due to normal vessel operations as well as to boiler tube blow-downs which purge steam vessel boilers of built-up carbon deposits. This purging emits a concentration of particulate matter that could alter the patterns of atmospheric loading on a local or regional basis. This could cause Federal or local air quality standards to be exceeded on a short- or long-term basis.

(2) Water Quality

Dredging activities, some dredge spoils disposal methods, and increased vessel traffic in connecting channels would result in the:

- Temporary suspension of silt, sediment and detritus, creating turbidity
- Short-term restriction of light availability to photosynthetic organisms
- Possible resuspension of organic or toxic laden sediments.

These impacts not only lower the quality of water but also possibly impair the functions of aquatic organisms.

In addition, the increased discharge of salt water ballast or treated or untreated sewage (for which further restrictive measures are presently being considered) accompanying greater vessel traffic may increase the levels of chemical pollutants and introduce foreign vertebrate/invertebrate/plant species in the waters.

With large increases in vessel traffic, the potential for oil spill and resultant adverse effects on natural resources would be increased. The extent of this impact is not known. There also is much concern about the increased potential of accidential spills of fuel and petroleum cargoes due to founderings and collisions.

However, improvements in navigation aids, scheduling and monitoring improvements, structural improvements (alignments and increased channel capacities, etc.), and improved emergency clean-up procedures would diminish this potential.

(3) Noise

Short- or long-term noise level depends on a combination of factors, including distance, wind and weather. It is an indicator of the quality of the environment and contributes to the aesthetic condition of an area. Sounds of dredging, construction activities and commercial vessel operations can be identified and quantified. However, it is difficult

to predict their impact at various locations and under various conditions. Impacts associated with lockage system improvements are expected to be less than the low level of noise impacts predicted with season extension.

(4) Shorelines and Sediment Transport

Dredging activities, increased propeller wash and other amplified effects of navigation may result in the erosion and transport of sediment along the relevant connecting channels. These shore damage impacts are difficult to quantify as they are dependent upon water depths, levels and flows, channel patterns and velocities and soil conditions. The more restrictive the channel, the greater potential exists for damaging effects of vessel drawdown.

4. IMPACTS ON THE QUALITY OF LIFE

It does not seem likely that lock improvements will affect quality of life values such as cultural resources, recreational resources and aesthetics. Most of these issues have been raised in connection with impacts resulting from winter season navigation and the disruption of ice cover, in particular. These areas are discussed briefly below.

(1) Cultural Resources

Cultural resources often cited include known archeological, historical and paleontological resources along shorelines, particularly harbor areas, and submerged historical structures. Included in this category are more than 6,000 shipwrecks scattered on the bottom of the Great Lakes. Impacts due to increased hydrological movements, propeller wash, and mechanical vibrations would be site-specific. In any event, these movements are not anticipated to be severe enough to create new substantive damage.

(2) Recreation and Aesthetic Values

The protection of the natural environment and related recreational and aesthetic resources are very important issues to the people and communities along the St. Lawrence River (particularly New York State). These values must be given significant consideration.

The Great Lakes Basin area is interested in the development of shoreland resources that will facilitate sound economic, social and environmental planning programs. These programs include:

- Flood plain management
- Recreation sites
- Forest land utilization
- River valley preserves
- Scenic easements.

In addition to servicing wildlife, they facilitate and promote aesthetic enjoyment and leisure-time pursuits such as:

- Hunting
- Fishing and ice-fishing
- Driving for pleasure
- Camping
- Access to resorts and recreational areas
- Snowmobiling
- Cross-country skiing
- Recreational boating (including ice-boating).

None of these activities would be expected to be directly affected by lockage system improvements. Indirect impacts could include a reduced fish population, degraded air and water qualities and reduced land availability for recreational boating facilities, due to the requirements for commercial vessel harbor facilities. However, the latter impact assumes land-constrained harbors which do not seem to be the general condition in the Great Lakes/St. Lawrence Seaway. Disturbances to cross-channel transportation have been cited as a result of the broken ice cover during the season extension, which would not be a factor in the lockage improvement program.

(3) Other Quality-of-Life Values

Other quality-of-life values that have been listed as susceptible to harm by the season extension include:

- Individual (occupational) safety and comfort

- "Psychosocial" stability, (stable and healthy morale and family relations)

- Stable employment patterns.

The first two are cited as applicable to specific occupational groups, such as pilots, vessel crew, and terminal and lock personnel, due to their exposure to severe winter weather conditions and accompanying increased personal risk. These weather conditions are not directly applicable to a lock improvement program.

The threat of localized unemployment is seen by some as the result of a permanent influx of temporary construction workers who are released at the conclusion of a project. In the long run, an overall increase in employment is projected with the season extension, and similar overall employment benefits under a lock improvement program are expected to negate any unemployment shifts due to program construction activities.

5. INSTITUTIONAL INTERESTS

Other important social issues for consideration are institutional interests and project support. System improvements would involve coordination and impact analysis at the national, regional and local levels. The issue of national and/or regional versus local interests is of particular concern for this portion of the overall study and must be given significant attention.

VII. INTERMODAL IMPACTS

This chapter evaluates the intermodal impacts of lock improvement programs. These impacts are measured in terms of the net increase or decrease of line-haul freight revenues accruing to the major segments of the U.S. freight carrier industry: railroads, motor carriers, barge operators and the U.S.-flag Great Lakes and foreign trade fleets.

The first section of the chapter describes the method used for this analysis. The second section presents the results of the analysis.

1. METHODOLOGY

The method used to estimate potential intermodal impacts of lock improvement programs consists of three elements:

- Identification of modal revenue shifts per ton of cargo
- Application to tonnage forecasts
- Identification of financial profiles of each mode.

Each of these elements is described below.

(1) Identification of Modal Revenue Shifts per Ton of Cargo

Major commodity movements were identified from the cargo flow data developed in Phase I of the study.* These cargo movements are shown in Tables VII-1 and VII-2 for the upper lock system (Soo Locks) and lower lock system (St. Lawrence Seaway and Welland Canal), respectively. The intermodal revenue impacts involving these major movements are based on the Great Lakes and alternative routes as shown in Tables VII-3 and VII-4.

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*Commodity Flow Forecasts, September 1981.

TABLE VII-1
Representative Cargo Movements (Upper Locks)

ACTUAL			REPRESENTATIVE OF			TOTAL LOCK SYSTEM TRAFFIC (1978)	
COMM	ORIG	DEST	ORIG	DEST	1978 TONS (000)	COMMOD	TONS (000)
Wheat	Duluth	Overseas	L. Superior	Overseas	5,078	Grains	23,857
Corn	Duluth	Overseas	L. Superior	Overseas	3,307		
Coal	Toledo	Duluth	All other (1)	L. Superior	5,122	Coal	7,664
Coal	Duluth	Detroit	Duluth	Detroit	2,542		
Iron ore	Duluth	Calumet	L. Superior	L. Michigan	23,094	Iron ore	67,877
Iron ore	Duluth	Toledo	L. Superior	L. Erie (2)	16,292		
Iron ore	Duluth	Cleveland	L. Superior	L. Erie (3)	17,837		
N.A.			N.A.			Other	8,001

(1) Primarily Lake Erie ports.
(2) Subsequent rail movement to inland destination.
(3) Waterside destination.

TABLE VII-2
Representative Cargo Movements (Lower Locks)

ACTUAL			REPRESENTATIVE OF			TOTAL LOCK SYSTEM TRAFFIC (1978)	
COMM	ORIG	DEST	ORIG	DEST	1978 TONS (000)	COMMOD	TONS (000)
Corn	Calumet	Overseas	L. Mich.	Overseas	2,744	Grains	28,751
Corn	Toledo	Overseas	L. Huron, L. Erie				
Iron ore	Canada-St. Lawrence	Calumet	Canada-St. Lawrence	L. Mich	2,616	Iron ore	13,826
	Canada-St. Lawrence	Cleveland	Canada-St. Lawrence	L. Erie &	6,954		
Other bulk	Overseas	Calumet	Overseas	L. Mich.	1,003	Other bulk	10,802
	Overseas	Toledo	Overseas	L. Erie & Detroit	1,011		
General cargo	Overseas	Calumet	Overseas	L. Mich.	527	General cargo	6,904
General cargo	Overseas	Toledo	Overseas	L. Erie & Detroit	477		
Steel	Overseas	Calumet	Overseas	L. Mich.	1,469		
	Overseas	Detroit	Overseas	L. Erie & Detroit	1,885		
N.A.			N.A.			Other	1,159

TABLE VII-3
Rates for Representative Movements (Upper Locks)
(Dollars per Short Ton)

				GREAT LAKES ROUTE				ALTERNATIVE ROUTE			
COMM	ORIG	DEST	WEIGHT (%) (1)	RAIL	TRUCK	LAKE	RAIL TO DEST.	RAIL	TRUCK	BARGE	(ROUTE)
Wheat	Duluth	Overseas	60%	21.67	7.05	9.00*	--	42.82	--	--	via Pac. N.W. ports
Corn	Duluth	Overseas	40%	12.05	2.13	9.60*	--	7.00	1.22	17.80	via New Orleans
Coal	Toledo	Duluth	67%	11.06	--	3.48	--	27.75	--	--	rail-mine to destination
Coal	Duluth	Detroit	33%	8.31	--	4.00	--	31.00	--	--	rail-mine to destination
Iron ore	Duluth	Calumet	40%	4.70	--	6.38	--	17.01	--	--	rail-Mesabi to destination
Iron ore	Duluth	Toledo	28%	4.70	--	5.93	7.47	11.56	--	--	rail-Labrador ore via East Coast
Iron ore	Duluth	Cleveland	32%	4.70	--	5.93	--	11.52	--	--	rail-Labrador ore via East Coast

(1) Source is 1978 tons as shown in Table VII-1.

*Lakes rate to St. Lawrence River ports.

TABLE VII-4
Rates for Representative Movements (Lower Locks)

COMM	ORIG	DEST	WEIGHT (%) (1)	GREAT LAKES ROUTE RAIL	GREAT LAKES ROUTE TRUCK	GREAT LAKES ROUTE LAKE	ALTERNATIVE ROUTE RAIL	ALTERNATIVE ROUTE TRUCK	ALTERNATIVE ROUTE BARGE	ALTERNATIVE ROUTE OCEAN LINER	(ROUTE)
Corn	Calumet	Overseas	43%	1.64	6.56	9.00	2.10	6.00	11.88	--	via New Orleans
Corn	Toledo	Overseas	57%	--	6.24	7.40	11.06	6.24	--	--	via East Coast
Iron ore	Can-St.L.	Calumet	27%	2.60	--	3.94	7.00	--	--	--	rail-Mesabi to destination
	Can-St.L.	Cleveland	73%	2.60	--	2.69	11.52	--	--	--	rail-Labrador ore via East Coast
Other bulk	Overseas	Calumet	50%	*	*	+	--	--	6.25	--	via New Orleans
	Overseas	Toledo	50%	*	*	+	12.50	--	--	--	via East Coast
General cargo	Overseas	Calumet	19%	*	*	+	--	--	--	--	via joint rail-water rate via Montreal
General cargo	Overseas	Toledo	18%	*	*	+	27.90	--	--	147.00	via East Coast
Steel	Overseas	Calumet	28%	*	*	+	--	--	11.00	52.50	via New Orleans
Steel	Overseas	Detroit	35%	*	*	+	34.60	--	--	34.50	via East Coast

*No inland movement, therefore no rate is shown.

+Usually carried in foreign-flag ships, so no revenue accrues to the U.S.-flag shipping sector and no rate is shown.

The tables are interpreted as follows. In Table VII-1, the first line indicates that the rates for the movement of wheat from Duluth to overseas are used as representative of all export wheat movements from Lake Superior ports. The rates for corn exports from Duluth are used as representative of corn exports from all Lake Superior ports. The relative tonnages (5,078,000 tons and 3,307,000 tons, respectively) are used to develop the weighting factors in Table VII-3. These two movements are about 35 percent of total grain exports (23,857,000 tons) from Lake Superior ports.

Some of the freight rates for transportation of Great Lakes traffic are paid to non-U.S. carriers. All bulk foreign trade is assumed to be carried in foreign-flag vessels, so no bulk ocean rates are shown in the tables. Two other adjustments to the rates were made in order to develop factors that reflect the revenues accruing to U.S. carriers, per ton of traffic through the locks. These adjustments are as follows:

- Revenues for rail movements in Canada (from mines to St. Lawrence River ports) were excluded.

- About 32 percent of the liner trade involving U.S. ports is carried by U.S.-flag vessels; most of this is non-steel general cargo. Therefore only 32 percent of the revenue accruing to the ocean carrier industry for non-steel general cargo was counted.

The rates in Table VII-3 indicate the following modal revenue shifts for grain using the upper lock system (a net revenue gain for the project case over the non-project case is indicated by a positive sign):

- Rail: - $10.67 per ton
- Truck: + $4.59 per ton
- Barge: - $7.12 per ton
- Laker vessel: + $9.24 per ton.

Net modal revenue shifts are summarized in Tables VII-5 and VII-6.

TABLE VII-5
Net Modal Revenue Shifts (Upper Locks)
(All Rates Are Dollars per Short Ton)

Mode	Route	Grain	Coal	Iron Ore
Rail	GL Route	$17.82	$10.15	$20.67
	Alt. Route	28.49	28.82	13.73
		($10.67)	($18.67)	($ 6.94)
Truck	GL Route	$ 5.08		
	Alt. Route	0.49	---	---
		$ 4.59		
Barge	GL Route	$ 0.00		
	Alt. Route	7.12	---	---
		($ 7.12)		
Lake Carrier	GL Route	$ 9.24	$ 3.65	$ 6.11
	Alt. Route	0.00	0.00	0.00
		$ 9.24	$ 3.65	$ 6.11

Source: Table VII-3.

(2) Application to Tonnage Forecasts

The previous section described the development of factors defining the net modal revenue shifts per ton of cargo. To use these factors to determine modal revenue impacts on U.S. transportation sectors, an identification of how much traffic would be impacted was made. Both U.S. and Canadian traffic will be forced to leave the Great Lakes system if capacity

TABLE VII-6
Net Modal Revenue Shifts (Lower Locks)
(All Rates Are Dollars per Short Ton)

Mode	Route	Grain	Iron Ore	Other Bulk	General Cargo
Rail	GL Route	$0.71	$ 2.60	$0.00	$ 0.00
	Alt. Route	7.21	10.30	6.25	17.13
		($6.50)	($ 7.70)	($6.25)	($17.13)
Truck	GL Route	$6.38	--	--	--
	Alt. Route	6.14			
		$0.24			
Barge	GL Route	$0.00	--	$0.00	$ 0.00
	Alt. Route	5.11		3.13	3.08
		($5.11)		($3.13)	($ 3.08)
Lake Carrier	GL Route	$8.09	$ 3.03		
	Alt. Route	0.00	0.00	--	--
		$8.09	$ 3.03		
Ocean Carrier	GL Route	--	--	--	$ 0.00
	Alt. Route				56.78
					($56.78)

is not increased. In order to compute U.S. intermodal impacts, this tonnage data must be adjusted to eliminate the following:

- Canada-Canada and Canada-overseas traffic
- U.S. traffic which does not use U.S.-flag water carriage.

The percentages used for these adjustments are shown in Table VII-7.

TABLE VII-7
Tonnage Adjustments

	U.S. Traffic as a Percent of Total	Percent of U.S. Traffic Carried by Lake Vessels
Upper Lock System		
Grain	42%	22%
Iron ore	98%	100%
Coal	95%	100%
Lower Lock System		
Grain	58%	36%
Iron ore	80%	100%

(3) <u>Identification of Financial Profiles of Each Mode</u>

The following sections provide financial profiles for the major modes serving the Great Lakes area:

- Railroads
- Motor carriers
- Tug and barge operators
- U.S. Great Lakes fleet
- U.S. foreign trade fleet.

Each section identifies current gross revenues, and growth factors or forecasts which indicate how these revenues are expected to increase in the future.

1. Railroad Industry Revenues

Table VII-8 shows base revenues of ten Class I U.S. railroads representing that segment of the industry which serves Great Lakes ports and the movements of commodities between Great Lakes hinterland states and Atlantic, Gulf and West Coast ports. Revenues for these ten railroads were calculated as 45 percent of the total freight revenue for all Class I railroads, following the same proportion evidenced for 1979 and 1978.

TABLE VII-8
Railroad Revenues (1980)
($000)

District	Railroad	Freight Revenue
Eastern	Baltimore & Ohio	$ 913,355
	Chesapeake & Ohio	904,078
	Conrail	3,153,584
	Grand Trunk Western	181,913
	Norfolk & Western	1,504,475
	Western Maryland	88,753
Southern	Illinois Central Gulf	891,388
	Burlington Northern	2,886,251
Western	Chicago & Northwestern	844,636
	Soo Lines	307,362
Total		11,675,795

Source: Railroad Revenues, Expenses, and Income-Class I Railroads in the U.S., Fourth Quarter 1980, Association of American Railroads, April 1, 1981.

The revenue forecast from 1980 to 2050 is based on an average annual growth rate of 2.58 percent. This is the annual average growth rate of forecasts presented in the Federal Railroad Administration's Railroad Freight Traffic Flows, 1990, December 1980.

2. Motor Carrier Industry Revenues

The only commodity in the study area using motor carrier line-haul transportation is grain; steel and general cargo are assumed to be produced or consumed in the metropolitan area of the port of entry or exit, and other bulk commodities use rail for intercity movements.

Gross revenues for the regulated common carrier industry was about $43 billion in 1979.* Regionalized revenue data available for some of the major segments of the industry indicate that about 31 percent of gross revenues were collected in the three ICC geographic regions bordering the Great Lakes:

- Central (Ohio, Michigan, Indiana and Illinois)
- Northwestern (Wisconsin, Minnesota, North Dakota and South Dakota)
- Midwestern (Iowa, Missouri, Nebraska and Kansas).

Therefore it is assumed that revenues collected in the Great Lakes hinterland in 1980 were about $13.3 billion. These revenues do not include motor carriers exempt from ICC regulation. The principal exempt commodity is grain. Annual revenues for exempt grain carriers were estimated as described in the following paragraphs.

Table VII-9 identifies receipts of grain by motor carriers. The eight-state Great Lakes area was used to include short distance grain movements; the thirteen-state area, to include motor carriers operating to East Coast states as well as to Great Lakes ports.

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*This and subsequent financial data were taken from the "1981 Financial Analysis of the Motor Carrier Industry," published by Citibank.

TABLE VII-9
U.S. Motor Carrier Grain Receipts (1977)
(1000 Tons)

	Intracity (1)	Intercity (2)	Total
Corn	30,208	7,067	37,275
Wheat	6,737	3,261	9,998
Soybeans	11,308	3,370	14,678
Total	48,253	13,698	61,951

Source: North Central Regional Research publications No. 273, 274, 275 of the College of Agriculture, Univ. of Illinois at Champaign-Urbana.

(1) 8 states around Great Lakes.
(2) 13 states including Great Lakes and Atlantic Coast ports.

A rate of $12 per ton was used to develop an estimate of annual revenue. This rate was the average rate of grain movements by regulated carriers in 1977.* This produces an annual revenue of $743 million in 1977. Revenues for 1980 were estimated using a 2 percent annual growth rate, indicating that exempt carrier revenues in the Great Lakes area were $788 million in 1980. Therefore total motor carrier revenue in the Great Lakes area is estimated to have been $14.1 billion in 1980. Revenues for future years were developed using a 2 percent annual growth rate.

3. Barge and Towing Industry Revenues

The movement of few if any products shipped on the Great Lakes currently involves the inland waterway system. The inland waterways would be used if a capacity condition developed in the Great Lakes and exports or imports were forced to use the Gulf Coast.

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*ICC freight commodity statistics.

The towing industry is not required to submit operating data to the ICC; a recent study indicates that total revenues for the towing industries in 1977 were estimated to be $2.14 billion; traffic is estimated to grow at 2.2 percent per year until the year 2000.*

4. <u>U.S. Lake Carrier Industry</u>

There were about 130 U.S.-flag ships operating in the Great Lakes in 1980.** Since many of these vessels are engaged in proprietary rather than common carrier operation, annual revenues have a different meaning compared to the industries discussed previously. As used in this section, annual revenue is a measure of the value of the transportation service provided. One large common carrier operating in the lakes reported an average revenue in 1980 of $2.86 per ton, based on 28,296 tons and gross revenues of $80.8 million.†

In 1978, total U.S. domestic traffic in the lakes was 150,774,000 tons, and U.S.-Canadian traffic was 50,878,000 tons.# Assuming that the U.S. fleet carries 100 percent of the domestic traffic (as required by the Jones Act) and 50 percent of the U.S.-Canada traffic, the industry carried a total of 176,213,000 tons in 1978. At an average revenue of $2.86 per ton, the industry received $504 million in 1978.

Revenues are expected to grow proportionally to the forecasts of total U.S. Great Lakes traffic developed earlier in this study. These forecasts indicated a growth rate of 2.6 percent until 1990, and between 1.3 percent and 1.6 percent between 1990 and 2050.

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*U.S. Department of Transportation, <u>Inland Waterway User Taxes and Charges</u>, February 1982.

**Annual Report of the Lake Carrier's Association.

†American Steamship Co., Annual Report

#Waterborne Commerce Statistics.

5. U.S.-Flag Liner Industry

Gross revenue of the nine U.S.-flag liner carriers engaged in foreign commerce was $4.3 billion in 1980.* MarAd trade forecasts predict a growth in liner tonnage of about 5 percent per year.

2. RESULTS OF THE ANALYSIS

Table VII-10 summarizes the results of the intermodal impact analysis for structural scenario number one, which consists of non-structural improvements to maximum utility, followed by 1350 X 115 foot locks. These impacts are summarized below:

- Lake carriers: The with-project case allows lake carriers to receive $10.3 million in revenue in 1985 that would have been lost if the system reached capacity. This revenue increases to $30.8 million in 2000 and $553 million by 2050. This represents 1.4 percent of this industry's revenue in 1985, increasing to 4.1 percent by 2000 and 36 percent by 2050.

- Railroads: The with-project case means a loss of the opportunity to collect $79 million in revenues in 1985, increasing to $140 million by the year 2000 and more than $1 billion in 2050. This is less than 2 percent of expected revenues in any of these years, however.

- Barge and towing industry: The with-project case means the loss of the opportunity to collect $25 million in revenue in 1985, increasing to $50 million in 2000 and $113 million in 2050. This is similarly less than 2 percent of total revenues in any of these years, however.

- Motor carriers: The with-project case means a change of less than 1 percent in any year until 2050.

- U.S.-Flag Liner Industry: The impact on the liner industry is negligible.

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*American Shipper, September 1981.

TABLE VII-10
Summary of Intermodal Impacts
($ million)

	1985	1990	2000	2010	2030	2050
Lake Carrier						
Total Revenue	573	650	759	874	1,141	1,150
Net Change	10.33	17.1	30.8	81	311	553
Percent Change	1.8%	2.6%	4.1%	9.3%	27.3%	36.1%
Railroads						
Total Revenue	13,369	15,063	19,433	25,071	41,728	69,452
Net Change	(79)	(99)	(140)	(246)	(668)	(1,030)
Percent Change	*	*	*	*	(1.6%)	(1.5%)
Motor Carriers						
Total Revenue	15,568	17,188	20,952	25,540	37,951	56,394
Net Change	0.7	1.0	1.5	2.7	9.8	17.0
Percent Change	*	*	*	*	*	*
Barge & Towing Industry						
Total Revenue	2,150	2,397	2,980	3,704	5,729	8,845
Net Change	(25)	(34)	(50)	(59)	(101)	(113)
Percent Change	(1.2%)	(1.4%)	(1.7%)	(1.6%)	(1.8%)	(1.3%)
U.S. Flag Liner Industry						
Total Revenue	5,488	7,004	11,409	13,907	20,665	30,708
Net Change	(20)	(18)	(14)	(15)	(52)	(64)
Percent Change	*	*	*	*	*	*

* Less than 1 percent.

Note: Reflects non-structural improvements to maximum utility, followed by 1350 x 115 foot locks.

A positive impact means that the with-project case benefits a modal industry by allowing it to be able to handle traffic which would otherwise be forced off the system. The modes affected positively are the lake carriers and motor carriers. A negative impact means that lock improvements cause a modal industry to lose the opportunity to move traffic which would have been forced off the system in the absence of improvements. The modes affected negatively are railroads, the barge and towing industry and the U.S.-flag liner industry. Except for the lake carriers, modal impacts even by the year 2050 are expected to remain at less than 2 percent of gross revenues.

The volume and commodity mix of the tonnage able to use the system after other types of structural improvements (larger locks and deeper channels) will be similar to those evaluated in the previous table. The intermodal impacts are expected to be similar as well.

DETAILED ENERGY IMPACT DATA

This appendix contains detailed information concerning the energy impacts of structural lock improvement programs.

Potential Energy Savings
(1350 X 115 Foot Locks)
(Billion Btus per Year)

	1985	1990	2000	2010	2020	2030	2040	2050
UPPER LOCK SYSTEM								
Iron ore				1,700	6,310	11,200	16,400	21,400
Coal				140	129	240	360	490
Grain				(130)	(505)	(980)	(1,430)	(2,030)
Stone				47	188	350	540	750
Other bulk				150	577	1,090	1,690	2,490
				1,907	6,699	11,900	17,560	23,100
LOWER LOCK SYSTEM								
Iron ore	63	210	380	314	510	617	770	850
Grain	(110)	(2,400)	(3,470)	(861)	(793)	(720)	(670)	(628)
Other bulk	23	62	126	161	350	573	770	930
General cargo	1,400	840	1,310	1,540	1,940	3,940	5,730	6,930
	1,596	(1,288)	(1,754)	1,154	2,007	4,410	6,600	8,082

Note: Includes non-structural improvements.

Potential Energy Savings
(32 Foot System Draft)
(Billion Btus per Year)

	1985	1990	2000	2010	2020	2030	2040	2050
UPPER LOCK SYSTEM								
Iron ore				1,700	6,310	11,200	15,400	15,400
Coal				140	129	240	330	330
Grain				(130)	(505)	(980)	1,360	1,360
Stone				47	188	350	500	500
Other bulk				150	577	1,090	1,590	1,590
				1,907	6,699	11,900	19,180	19,180
LOWER LOCK SYSTEM								
Iron ore	63	210	380	314	510	617	720	780
Grain	(110)	(2,400)	(3,570)	(861)	(793)	(720)	(685)	(654)
Other bulk	23	62	126	151	350	373	514	850
General cargo	1,400	840	1,230	1,720	2,360	4,640	5,930	6,730
	1,376	(1,288)	(1,834)	1,324	2,427	4,910	6,479	7,706

Note: Includes non-structural improvements.

Potential Energy Savings
(28 Foot System Draft)
(Billion Btus per Year)

	1985	1990	2000	2010	2020	2030	2040	2050
UPPER LOCK SYSTEM								
Iron ore				1,700	6,310	9,200	9,200	9,200
Coal				140	129	194	194	194
Grain				(130)	(505)	(790)	(790)	(790)
Stone				47	188	290	290	290
Other bulk				150	577	890	890	890
				1,907	6,699	9,784	9,784	9,784
LOWER LOCK SYSTEM								
Iron ore	63	210	380	314	430	427	467	467
Grain	(110)	(2,400)	(3,470)	(861)	(823)	(786)	(772)	(772)
Other bulk	23	62	126	161	302	434	501	501
General cargo	1,400	840	1,230	1,720	1,920	3,130	3,620	3,620
	1,596	(1,288)	(1,834)	1,334	1,829	3,205	3,816	3,816

Note: Includes non-structural improvements.

Potential Energy Savings
(1460 X 145 Foot Locks)
(Billion Btus per Year)

	1985	1990	2000	2010	2020	2030	2040	2050
UPPER LOCK SYSTEM								
Iron ore				1,700	6,310	11,200	16,400	21,400
Coal				140	129	240	360	490
Grain				(130)	(505)	(980)	(1,430)	(2,030)
Stone				47	188	350	540	750
Other bulk				150	577	1,090	1,690	2,490
				1,907	6,699	11,900	17,560	23,100
LOWER LOCK SYSTEM								
Iron ore	63	210	380	314	510	617	840	1,030
Grain	(110)	(2,400)	(3,570)	(861)	(837)	(720)	(649)	(560)
Other bulk	23	62	126	161	350	573	630	1,110
General cargo	1,400	840	1,310	1,540	1,940	3,940	6,430	5,530
	1,596	(1,288)	(1,754)	1,154	1,963	5,060	7,251	10,110

Note: Includes non-structural improvements.

DETAILED REGIONAL ECONOMIC IMPACT DATA

This appendix contains detailed information concerning regional economic impacts resulting from 1350 by 115 foot locks. Forecasts of the following are provided for major U.S. Great Lakes ports:

- Bulk and general cargo tonnage able to be handled because of the improvement
- Resulting port-related employment
- Resulting annual port-related income.

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GREAT LAKES/SAINT LAWRENCE SEAWAY REGIONAL TRANSPORTATION STUDY--ETC(U)
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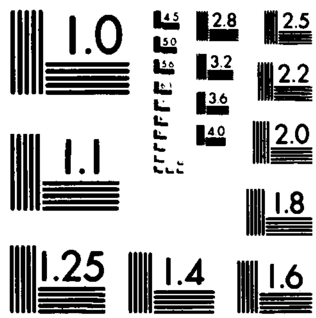

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963 A

Bulk Cargo (1000 tons)

	1980	1985	1990	2000	2010	2020	2030	2040	2050
TWO HBRS	0	0	0	0	971	3611	6335	9428	12619
DULUTH-SUP	0	1336	1723	976	4613	10524	18069	26186	34647
PRESQUE IS	0	0	0	0	398	1453	2605	3805	5130
MARQUETTE	0	0	0	0	0	0	0	0	0
TACONITE	0	0	0	0	816	2863	5106	7497	10012
SILVER BAY	0	0	0	0	881	3263	5792	8350	11202
ASHLAND	0	0	0	0	13	51	94	143	197
GREEN BAY	0	0	0	0	0	0	0	1	1
MILWAUKEE	0	7	29	63	106	159	224	259	264
CHICAGO	0	0	1	1	2	3	4	5	5
CALUMET HB	0	598	744	1282	2614	5001	7582	9713	11258
INDIANA HB	0	0	20	62	780	2515	4363	6421	8376
BURNS HBR	0	19	54	100	668	1832	3259	4602	5950
MUSKEGON	0	0	0	0	1	4	9	14	21
GARY	0	82	130	195	994	3006	5140	7495	9909
ESCANABA	0	0	0	0	9	34	61	91	123
GRND HAVEN	0	0	0	0	0	0	0	0	0
LUDINGTON	0	1	4	10	21	37	63	80	80
BUFFINGTON	0	6	14	34	59	94	139	168	181
PT.DOLOMIT	0	0	0	0	2	10	19	30	44
PT. INLAND	0	0	2	3	5	7	10	11	11
PT WSHNGTN	0	0	0	0	7	30	58	94	139
SAGINAW	0	0	0	0	0	0	0	0	0
ST.CLAIR R	0	0	0	0	31	0	0	0	0
DETROIT	0	44	191	395	1278	3186	5394	7527	9396
TOLEDO	0	255	63	125	965	3048	5498	7744	9949
SANDUSKY	0	0	1	2	13	44	78	116	157
HURON	0	4	16	30	83	397	735	1051	1163
LORAIN	0	0	33	72	432	1357	2076	2913	3809
CLEVELAND	0	70	338	767	1844	4081	6254	8116	10263
ASHTABULA	0	2	31	295	942	2106	3526	4702	5859
CONNEAUT	0	103	392	761	1707	3475	5358	7112	8681
ERIE	0	11	29	57	84	115	151	168	168
BUFFALO	0	123	319	596	1272	2265	3479	4413	5253
MONROE	0	0	0	0	0	0	0	0	0
FAIRPORT	0	5	11	23	37	53	72	81	81
MARBLEHEAD	0	0	2	4	7	11	15	17	17
OSWEGO	0	4	18	32	67	145	234	322	392
ROCHESTER	0	0	0	0	0	0	0	0	0
OTH ST.LAW	0	9	22	50	79	114	154	174	174
OTH L.ONT	0	0	1	2	3	4	5	5	5
OTH L.ERIE	0	0	0	0	0	0	0	0	0
OTH DET R.	0	2	6	11	19	28	38	44	46
OTH ST MAR	0	0	0	0	0	0	0	0	0
OTH L.HURN	0	33	49	69	1293	1235	2276	3480	4881
OTH L.MICH	0	5	11	26	42	64	91	107	110
ST.MARYS-A	0	2	11	21	52	119	198	279	366
OTH L.SUP	0	0	0	0	13	51	95	147	208
TOTAL	0	2721	4265	6064	23223	56395	94659	132911	171147

General Cargo (1000 tons)

	1980	1985	1990	2000	2010	2020	2030	2040	2050
TWO HBRS	0	0	0	0	0	0	0	0	0
DULUTH-SUP	0	29	21	42	81	95	168	202	212
PRESQUE IS	0	0	0	0	0	0	0	0	0
MARQUETTE	0	0	0	0	0	0	0	0	0
TACONITE	0	0	0	0	0	0	0	0	0
SILVER BAY	0	0	0	0	1	0	5	11	17
ASHLAND	0	0	0	0	0	0	0	0	0
GREEN BAY	0	4	9	19	33	51	72	85	91
MILWAUKEE	0	41	36	74	134	157	259	302	305
CHICAGO	0	18	21	43	74	93	141	162	162
CALUMET HB	0	759	350	500	1084	631	1934	2408	2419
INDIANA HB	0	1	2	4	7	10	13	15	15
BURNS HBR	0	135	65	98	207	138	381	465	465
MUSKEGON	0	1	2	5	9	14	21	25	28
GARY	0	0	0	0	0	0	0	0	0
ESCANABA	0	0	0	0	0	0	0	0	0
GRND HAVEN	0	0	0	0	0	0	0	0	0
LUDINGTON	0	0	0	0	0	1	2	3	4
BUFFINGTON	0	0	0	0	0	0	0	0	0
PT.DOLOMIT	0	0	0	0	0	0	0	0	0
PT. INLAND	0	0	0	0	0	0	0	0	0
PT WSHNGTN	0	0	0	0	0	0	0	0	0
SAGINAW	0	0	0	0	0	0	0	0	0
ST.CLAIR R	0	0	0	1	2	2	3	4	4
DETROIT	0	1163	552	691	1363	751	2344	2882	2882
TOLEDO	0	234	119	182	374	284	702	856	867
SANDUSKY	0	0	0	0	0	0	0	0	0
HURON	0	0	0	1	2	2	3	3	3
LORAIN	0	0	0	0	0	0	0	0	0
CLEVELAND	0	407	177	205	438	166	723	895	895
ASHTABULA	0	2	5	12	24	43	64	82	96
CONNEAUT	0	0	0	0	0	0	0	0	0
ERIE	0	109	46	65	146	80	275	338	338
BUFFALO	0	1	2	4	7	8	16	23	29
MONROE	0	0	0	0	0	0	0	0	0
FAIRPORT	0	0	0	0	0	0	0	0	0
MARBLEHEAD	0	0	0	0	0	0	0	0	0
OSWEGO	0	1	2	5	12	24	37	50	59
ROCHESTER	0	0	0	0	0	0	0	0	0
OTH ST.LAW	0	0	0	0	0	0	0	0	0
OTH L.ONT	0	0	0	0	0	0	0	0	0
OTH L.ERIE	0	0	0	0	0	0	0	0	0
OTH DET R.	0	4	8	19	31	43	59	66	66
OTH ST MAR	0	0	0	0	0	0	0	0	0
OTH L.HURN	0	3	7	15	26	40	57	68	74
OTH L.MICH	0	4	10	23	37	54	73	82	82
ST.MARYS-A	0	0	0	0	0	0	0	0	0
OTH L.SUP	0	0	0	0	0	0	0	0	0
TOTAL	0	2916	1434	2008	4092	2687	7352	9027	9113

Employment (No. of Jobs) - Bulk Cargo

	1980	1985	1990	2000	2010	2020	2030	2040	2050
TWO HBRS	0	0	0	0	58	216	380	565	757
DULUTH-SUP	0	80	103	58	276	631	1084	1571	2078
PRESQUE IS	0	0	0	0	23	87	156	228	307
MARQUETTE	0	0	0	0	0	0	0	0	0
TACONITE	0	0	0	0	48	171	306	449	600
SILVER BAY	0	0	0	0	52	195	347	501	672
ASHLAND	0	0	0	0	0	3	5	8	11
GREEN BAY	0	0	0	0	0	0	0	0	0
MILWAUKEE	0	0	1	3	6	9	13	15	15
CHICAGO	0	0	0	0	0	0	0	0	0
CALUMET HR	0	35	44	76	156	300	454	582	675
INDIANA HR	0	0	1	3	46	150	261	385	502
BURNS HBR	0	1	3	6	40	109	195	276	357
MUSKEGON	0	0	0	0	0	0	0	0	1
GARY	0	4	7	11	59	180	308	449	594
ESCANABA	0	0	0	0	0	2	3	5	7
GRND HAVEN	0	0	0	0	0	0	0	0	0
LUDINGTON	0	0	0	0	1	2	3	4	4
BUFFINGTON	0	0	0	2	3	5	8	10	10
PT.DOLOMIT	0	0	0	0	0	0	1	1	2
PT. INLAND	0	0	0	0	0	0	0	0	0
PT WSHNGTN	0	0	0	0	0	1	3	5	8
SAGINAW	0	0	0	0	0	0	0	0	0
ST.CLAIR R	0	0	0	0	1	0	0	0	0
DETROIT	0	2	11	23	76	191	323	451	563
TOLEDO	0	15	3	7	57	182	329	464	596
SANDUSKY	0	0	0	0	0	2	4	6	9
HURON	0	0	0	1	4	23	44	63	69
LORAIN	0	0	1	4	25	81	124	174	228
CLEVELAND	0	4	20	46	110	244	375	486	615
ASHTABULA	0	0	1	17	56	126	211	282	351
CONNEAUT	0	6	23	45	102	208	321	426	520
ERIE	0	0	1	3	5	6	9	10	10
BUFFALO	0	7	19	35	76	[illegible]	208	264	315
MONROE	0	0	0	0	0	[illegible]	0	0	0
FAIRPORT	0	0	0	1	2	[illegible]	4	4	4
MARBLEHEAD	0	0	0	0	0	[illegible]	0	1	1
OSWEGO	0	0	1	1	4	8	14	19	23
ROCHESTER	0	0	0	0	0	0	0	0	0
OTH ST.LAW	0	0	1	3	4	6	9	10	10
OTH L.ONT	0	0	0	0	0	0	0	0	0
OTH L.ERIE	0	0	0	0	0	0	0	0	0
OTH DET R.	0	0	0	0	1	1	2	2	2
OTH ST MAR	0	0	0	0	0	0	0	0	0
OTH L.HURN	0	1	2	4	77	74	136	208	292
OTH L.MICH	0	0	0	1	2	3	5	6	6
ST.MARYS-A	0	0	0	1	3	7	11	16	21
OTH L.SUP	0	0	0	0	0	3	5	8	12
TOTAL	0	163	255	363	1393	3383	5679	7974	10268

Employment (No. of Jobs) - General Cargo

	1980	1985	1990	2000	2010	2020	2030	2040	2050
TWO HBRS	0	0	0	0	0	0	0	0	0
DULUTH-SUP	0	42	30	60	117	137	243	292	307
PRESQUE IS	0	0	0	0	0	0	0	0	0
MARQUETTE	0	0	0	0	0	0	0	0	0
TACONITE	0	0	0	0	0	0	0	0	0
SILVER BAY	0	0	0	0	1	0	7	15	24
ASHLAND	0	0	0	0	0	0	0	0	0
GREEN BAY	0	5	13	27	47	73	104	123	131
MILWAUKEE	0	59	52	107	194	227	375	437	442
CHICAGO	0	26	30	62	107	134	204	234	234
CALUMET HB	0	1100	507	725	1571	914	2804	3491	3507
INDIANA HB	0	1	2	5	10	14	18	21	21
BURNS HBR	0	195	94	142	300	200	552	674	674
MUSKEGON	0	1	2	7	13	20	30	36	40
GARY	0	0	0	0	0	0	0	0	0
ESCANABA	0	0	0	0	0	0	0	0	0
GRND HAVEN	0	0	0	0	0	0	0	0	0
LUDINGTON	0	0	0	0	0	1	2	4	5
BUFFINGTON	0	0	0	0	0	0	0	0	0
PT.DOLOMIT	0	0	0	0	0	0	0	0	0
PT. INLAND	0	0	0	0	0	0	0	0	0
PT WSHNGTN	0	0	0	0	0	0	0	0	0
SAGINAW	0	0	0	0	0	0	0	0	0
ST.CLAIR R	0	0	0	1	2	2	4	5	5
DETROIT	0	1686	800	1001	1976	1088	3398	4178	4178
TOLEDO	0	339	172	263	542	411	1017	1241	1257
SANDUSKY	0	0	0	0	0	0	0	0	0
HURON	0	0	0	1	2	2	4	4	4
LORAIN	0	0	0	0	0	0	0	0	0
CLEVELAND	0	590	256	297	635	240	1048	1297	1297
ASHTABULA	0	2	7	17	34	62	92	118	139
CONNEAUT	0	0	0	0	0	0	0	0	0
ERIE	0	158	66	94	211	116	398	490	490
BUFFALO	0	1	2	5	10	11	23	33	42
MONROE	0	0	0	0	0	0	0	0	0
FAIRPORT	0	0	0	0	0	0	0	0	0
MARBLEHEAD	0	0	0	0	0	0	0	0	0
OSWEGO	0	1	2	7	17	34	53	72	85
ROCHESTER	0	0	0	0	0	0	0	0	0
OTH ST.LAW	0	0	0	0	0	0	0	0	0
OTH L.ONT	0	0	0	0	0	0	0	0	0
OTH L.ERIE	0	0	0	0	0	0	0	0	0
OTH DET R.	0	5	11	27	44	62	85	95	95
OTH ST MAR	0	0	0	0	0	0	0	0	0
OTH L.HURN	0	4	10	21	37	58	82	98	107
OTH L.MICH	0	5	14	33	53	78	105	118	118
ST.MARYS-A	0	0	0	0	0	0	0	0	0
OTH L.SUP	0	0	0	0	0	0	0	0	0
TOTAL	0	4228	2079	2911	5933	3896	10660	13089	13213

Income ($ Million) - Bulk Cargo

	1980	1985	1990	2000	2010	2020	2030	2040	2050
TWO HBRS	0	0	0	0	1	5	9	14	18
DULUTH-SUP	0	2	2	1	6	15	27	39	51
PRESQUE IS	0	0	0	0	0	2	3	5	7
MARQUETTE	0	0	0	0	0	0	0	0	0
TACONITE	0	0	0	0	1	4	7	11	15
SILVER BAY	0	0	0	0	1	4	8	12	16
ASHLAND	0	0	0	0	0	0	0	0	0
GREEN BAY	0	0	0	0	0	0	0	0	0
MILWAUKEE	0	0	0	0	0	0	0	0	0
CHICAGO	0	0	0	0	0	0	0	0	0
CALUMET HB	0	0	1	1	3	7	11	14	16
INDIANA HB	0	0	0	0	1	3	6	9	12
BURNS HBR	0	0	0	0	1	2	4	6	8
MUSKEGON	0	0	0	0	0	0	0	0	0
GARY	0	0	0	0	1	4	7	11	14
ESCANABA	0	0	0	0	0	0	0	0	0
GRND HAVEN	0	0	0	0	0	0	0	0	0
LUDINGTON	0	0	0	0	0	0	0	0	0
BUFFINGTON	0	0	0	0	0	0	0	0	0
PT.DOLOMIT	0	0	0	0	0	0	0	0	0
PT. INLAND	0	0	0	0	0	0	0	0	0
PT WSHNGTN	0	0	0	0	0	0	0	0	0
SAGINAW	0	0	0	0	0	0	0	0	0
ST.CLAIR R	0	0	0	0	0	0	0	0	0
DETROIT	0	0	0	0	1	4	8	11	14
TOLEDO	0	0	0	0	1	4	8	11	14
SANDUSKY	0	0	0	0	0	0	0	0	0
HURON	0	0	0	0	0	0	1	1	1
LORAIN	0	0	0	0	0	2	3	4	5
CLEVELAND	0	0	0	1	2	6	9	12	15
ASHTABULA	0	0	0	0	1	3	5	7	8
CONNEAUT	0	0	0	1	2	5	8	10	13
ERIE	0	0	0	0	0	0	0	0	0
BUFFALO	0	0	0	0	1	3	5	6	7
MONROE	0	0	0	0	0	0	0	0	0
FAIRPORT	0	0	0	0	0	0	0	0	0
MARBLEHEAD	0	0	0	0	0	0	0	0	0
OSWEGO	0	0	0	0	0	0	0	0	0
ROCHESTER	0	0	0	0	0	0	0	0	0
OTH ST.LAW	0	0	0	0	0	0	0	0	0
OTH L.ONT	0	0	0	0	0	0	0	0	0
OTH L.ERIE	0	0	0	0	0	0	0	0	0
OTH DET R.	0	0	0	0	0	0	0	0	0
OTH ST MAR	0	0	0	0	0	0	0	0	0
OTH L.HURN	0	0	0	0	1	1	3	5	7
OTH L.MICH	0	0	0	0	0	0	0	0	0
ST.MARYS-A	0	0	0	0	0	0	0	0	0
OTH L.SUP	0	0	0	0	0	0	0	0	0
TOTAL	0	4	6	9	34	84	141	199	256

Income ($ Million) - General Cargo

	1980	1985	1990	2000	2010	2020	2030	2040	2050
TWO HBRS	0	0	0	0	0	0	0	0	0
DULUTH-SUP	0	0	0	1	2	3	5	6	6
PRESQUE IS	0	0	0	0	0	0	0	0	0
MARQUETTE	0	0	0	0	0	0	0	0	0
TACONITE	0	0	0	0	0	0	0	0	0
SILVER BAY	0	0	0	0	0	0	0	0	0
ASHLAND	0	0	0	0	0	0	0	0	0
GREEN BAY	0	0	0	0	1	1	2	2	2
MILWAUKEE	0	1	1	2	4	5	8	9	9
CHICAGO	0	0	0	1	2	2	4	5	5
CALUMET HB	0	24	11	16	34	20	61	77	77
INDIANA HB	0	0	0	0	0	0	0	0	0
BURNS HBR	0	4	2	3	6	4	12	14	14
MUSKEGON	0	0	0	0	0	0	0	0	0
GARY	0	0	0	0	0	0	0	0	0
ESCANABA	0	0	0	0	0	0	0	0	0
GRND HAVEN	0	0	0	0	0	0	0	0	0
LUDINGTON	0	0	0	0	0	0	0	0	0
BUFFINGTON	0	0	0	0	0	0	0	0	0
PT.DOLOMIT	0	0	0	0	0	0	0	0	0
PT. INLAND	0	0	0	0	0	0	0	0	0
PT WSHNGTN	0	0	0	0	0	0	0	0	0
SAGINAW	0	0	0	0	0	0	0	0	0
ST.CLAIR R	0	0	0	0	0	0	0	0	0
DETROIT	0	37	17	22	43	24	75	92	92
TOLEDO	0	7	3	5	11	9	22	27	27
SANDUSKY	0	0	0	0	0	0	0	0	0
HURON	0	0	0	0	0	0	0	0	0
LORAIN	0	0	0	0	0	0	0	0	0
CLEVELAND	0	13	5	6	14	5	23	28	28
ASHTABULA	0	0	0	0	0	1	2	2	3
CONNEAUT	0	0	0	0	0	0	0	0	0
ERIE	0	3	1	2	4	2	8	10	10
BUFFALO	0	0	0	0	0	0	0	0	0
MONROE	0	0	0	0	0	0	0	0	0
FAIRPORT	0	0	0	0	0	0	0	0	0
MARBLEHEAD	0	0	0	0	0	0	0	0	0
OSWEGO	0	0	0	0	0	0	1	1	1
ROCHESTER	0	0	0	0	0	0	0	0	0
OTH ST.LAW	0	0	0	0	0	0	0	0	0
OTH L.ONT	0	0	0	0	0	0	0	0	0
OTH L.ERIE	0	0	0	0	0	0	0	0	0
OTH DET R.	0	0	0	0	0	1	1	2	2
OTH ST MAR	0	0	0	0	0	0	0	0	0
OTH L.HURN	0	0	0	0	0	1	1	2	2
OTH L.MICH	0	0	0	0	1	1	2	2	2
ST.MARYS-A	0	0	0	0	0	0	0	0	0
OTH L.SUP	0	0	0	0	0	0	0	0	0
TOTAL	0	93	45	64	130	85	235	288	291

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